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INTRODUCTION

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INTRODUCTION

This manual has been developed to provide guidance and assistance to highway design personnel in the practices and procedures for the detailed design of highways and the preparation of contract plans.

The principal objectives of the manual are:

- To document Department policies with regard to standards of design and procedures for development of contract plans.
- To define criteria to guide judgments and decisions made by highway design personnel.
- To describe the most effective design techniques and procedures and to present charts, tables and other information found to be useful by designers.

The material in the manual has been reviewed and edited by a committee of Department personnel who are knowledgeable of current design requirements and procedures. In this first edition, emphasis has been placed principally on compiling and documenting policies and procedures currently being followed as a result of various memoranda and verbal instructions. New and improved procedures have been incorporated in the manual when it was evident that they would be more effective.

This initial publication should not be considered a completed comprehensive design manual -- rather it is a first step toward orderly documentation of policies, procedures, instructions and guides.

Those persons who use the manual can contribute to its continuing improvement by submitting suggestions to the Manager, Special Assignments Unit, for ways in which the manual can be made more useful and practical. The Manager will periodically assemble a committee of persons capable of acting on the suggestions for improving this manual. The committees will be chaired by the Manager and will designate the improvements to be incorporated.

Throughout the manual, reference is made to Standard Drawings. Recently all Standard Drawings have been revised and up-dated. Each designer should have access to a current set of Standard Drawings as a reference source.

A companion Road Design Management Manual has been prepared to define a system of work flow for the design function, the various relationships and responsibilities, and procedures for planning, scheduling and controlling design work. Design managers should be familiar with the management manual.

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NOTES SHEET

General Requirements

A notes sheet will be included in each set of contract plans. Notes sheets will be similar to the model on the next page. One sheet will be used solely for notes, except where the notes can be readily placed on the same sheet with the table of contents.

Contents

Notes sheets will provide general information necessary for plan users to obtain a complete understanding of the contract plans. Examples of information to be included, if applicable, are listed below:

- Descriptions of items to be removed by non-contractor personnel
- Instructions for the contractor regarding items not to be disturbed, clearing and grubbing and dump areas
- Descriptions of work items absorbed in the costs of bid items
- Bases for plan quantities of surfacing materials
- Skew diagram for culverts
- Instructions for interpreting the plans, such as:
    - + "R/W line = control of access line unless otherwise noted"
    - + "See X-sections for cut and fill slope ratios. Backslopes will be rounded according to standard drawings."
    - + "Embankment quantities on the plans include shrinkage unless otherwise noted."
    - + Special instructions required to interpret the plans, such as the upper limits used to compute culvert excavation.

Drafting

Notes sheets should be drafted as follows:

Leroy:	Sheet heading	425 template
	Subheadings	200 template
Handletter:	Other information	No. 1 pen

STATE	PROJECT NO.	SHEET NO.
MONTANA	I-IG-15-7(13)323	5

NOTES

MISC. TO BE MOVED OR REMOVED BY OTHERS *

LOCATION	DESCRIPTION
24+25 TO 35+75	R.R TRACK LT OF SOLLID ROAD
10+00	BRASS CAP REFERENCE MONUMENT LT AND RT
10+00	2-1000 GAL. GAS TANKS LT. OF "C" LINE

ALL PRIVATELY OWNED SIGNS TO BE REMOVED BY OWNER.
ALL GUARDRAIL, GUIDE POSTS, SNOWFENCE AND STATE OWNED SIGNS TO BE MOVED BY STATE FORCES.

*UNLESS OTHERWISE SPECIFIED, ITEMS WITHIN THE R/W LIMITS WILL BE REMOVED OR MOVED BY OTHERS.

THE ABOVE SHOWN PUBLIC LAND SURVEY MONUMENTS TO BE REMOVED AND RESET BY STATE FORCES

CONSTRUCTION NOTE

CONTRACTOR TO USE EXTREME CAUTION WHEN WORKING AROUND TRANSMISSION LINE POLES LOCATED LT OF THE FOLLOWING STATIONS

593+00	659+75	703+44	748+97
655+97	681+25	712+16	820+54

DO NOT DISTURB

STA 4+06 ON "C" LINE DO NOT DISTURB WATER VALVE IN PL RT

CLEARING AND GRUBBING

TO BE ABSORBED IN UNIT PRICE BID FOR EXCAVATION
CLEARING & GRUBBING TO CONST. LIMITS PLUS 10 FEET

DUMP AREA

THE DUMP AREA FROM STA 276±00 TO STA 285±00 SHALL BE EXCAVATED TO THE LINES SHOWN ON THE X-SECTIONS AND DISPOSED OF AT THE DISCRETION OF THE CONTRACTOR WITH THE CONCURRENCE OF THE ENGINEER THE APPROXIMATE QUANTITY INVOLVED IS 39,457 C.Y.
SEE SPECIAL PROVISIONS

FURROW DITCHES

TO BE PLACED ALONG THE TOP OF CUT SECTIONS AS DIRECTED BY THE ENGINEER AND THE COST TO BE ABSORBED IN THE OTHER ITEMS OF THE CONTRACT.

APPROACHES

(STD DWG NO 20-01)

24 0' FUT FIN TOP WIDTH - 36 0' SUB-GRADE WIDTH AVERAGE LENG = 80'
ALL APPROACHES SURFACED TO R/W UNLESS OTHERWISE NOTED.
0.25' COMP PLANT MIX SURF - TYPE 3
0 20' COMP CR TOP SURF.
0 50' COMP CR BASE CRSE TYPE "A" GR-5
PRIME - MC-70

QUANTITIES FOR ONE APPROACH AVE LENGTH 80'

PLANT MIX SURF - TYPE 3	21 TONS
CR TOP SURF TYPE "A" GR 2	29 TONS
CR BASE CRSE TYPE "A" GR 5	85 TONS
PRIME-MC-70	0 3 TONS

BASIS OF PLAN QUANTITIES

(QUANTITIES FOR ESTIMATING PURPOSES ONLY)

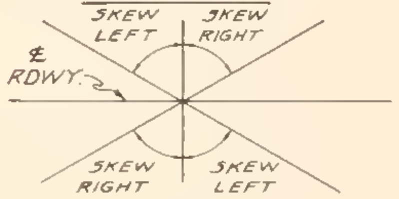
GRAVEL WT EST = 3700 LBS. PER C.Y.
PLANT MIX BIT MAT'L. = 6 5 % WEIGHT OF PLANT MIX MATERIAL 120-150 PENN.
PRIME = 0 30 GAL'S. PER S.Y. ~ MC-70
COMP WT OF PL MIX BIT SURF = 128 500 LBS PER TENTH PER S.Y.
BITUM. MAT'L = 8 5 LBS PER GALLON
TACK COAT = USE 0.1 GAL. PER S.Y. ~ GRADE SS-1
AVERAGE SUPER = 0.05' PER 10'

R/W LINE = CONTROL OF ACCESS UNLESS OTHERWISE NOTED

SLOPES

SEE X-SECTIONS FOR CUT AND FILL SLOPE RATIOS.
BACKSLOPES WILL BE ROUNDED IN ACCORDANCE WITH STANDARD DRAWING INFORMATION.

SKEW DIAGRAM



LINEAR AND LEVEL DATA SHEET

General Requirements

A linear and level data sheet will be included in each set of contract plans. Linear and level data sheets will be prepared similar to the model on the next page. One sheet will be used solely for linear and level data, except where they can be readily placed on the same sheet with the table of contents and notes.

Linear and level data sheets will show a summary of project lengths, a tabulation of bench mark data and the sources of bearing and level data.

Project Lengths

Project lengths will be summarized by showing roadway lengths, bridge lengths and total lengths for the following:

- Separate routes
- 2-lane and 4-lane sections of highway
- Sections of highway financed separately

Formats of length summaries will clearly identify the sections for which individual lengths must be shown. Four examples of length summaries are shown on the model sheet.

Bench Mark Data

Bench mark tabulations will show the station, elevation, location, description and elevation of each bench mark. Bench marks having locations referenced to the mainline will be shown first, followed by bench marks referenced to other lines in the order they appear along the mainline.

The road or line to which a group of bench marks is referenced will be conspicuously shown. Each group of bench marks will be tabulated in the order of increasing stations.

Drafting

Linear and level data sheets should be drafted as follows:

Leroy:	Sheet heading	425 template
	Subheadings	200 template
Handletter:	Other information	No. 1 pen

STATE	PROJECT NO	SHEET NO.
MONTANA	I IG 15-7(13)328	6

LINEAR AND LEVEL DATA

LENGTH OF ROADWAY	I-90 ROUTE 4-LANE I-90-8(26) 451	15,432.0 FT	=	2.923 MI
LENGTH OF BRIDGES	I-90 ROUTE 4-LANE I-90-8(26) 451	149.5 FT.	=	0.028 MI.
TOTAL LENGTH OF	I-90 ROUTE 4-LANE I-90-8(26) 451	15,581.5 FT	=	2.951 MI.
LENGTH OF ROADWAY	I-90 ROUTE EASTBOUND I-90-8(26) 451	2,649.0 FT	=	0.501 MI
LENGTH OF BRIDGES	I-90 ROUTE EASTBOUND I-90-8(26) 451	0.0 FT	=	0.000 MI.
TOTAL LENGTH OF	I-90 ROUTE EASTBOUND I-90-8(26) 451	2,649.0 FT	=	0.501 MI.
LENGTH OF ROADWAY	I-90 ROUTE WESTBOUND I-90-8(26) 451	3,723.4 FT	=	0.705 MI.
LENGTH OF BRIDGES	I-90 ROUTE WESTBOUND I-90-8(26) 451	283.1 FT.	=	0.054 MI.
TOTAL LENGTH OF	I-90 ROUTE WESTBOUND I-90-8(26) 451	4,006.5 FT	=	0.759 MI.
TOTAL AVE LENGTH	I-90 ROUTE 2-LANE I-90-8(26) 451	3,327.8 FT	=	0.630 MI.
LENGTH OF ROADWAY	I-94 ROUTE 4-LANE I-90-8(26) 451	3,585.0 FT.	=	0.679 MI
LENGTH OF BRIDGES	I-94 ROUTE 4-LANE I-90-8(26) 451	0.0 FT.	=	0.000 MI.
TOTAL LENGTH OF	I-94 ROUTE 4-LANE I-90-8(26) 451	3,585.0 FT.	=	0.679 MI.
TOTAL LENGTH OF	I-90 ROUTE I-90-8(26) 451	18,909.3 FT	=	3.581 MI
TOTAL LENGTH OF	I-90 & I-94 ROUTE I-90-8(26) 451	22,494.3 FT.	=	4.260 MI.

LENGTH OF ROADWAY	I-94-3(23) 105 4-LANE	39,257.5 FT	=	7.435 MI.
LENGTH OF BRIDGES	I-94-3(23) 105 4-LANE	418.0 FT.	=	0.079 MI.
TOTAL LENGTH OF	I-94-3(23) 105 4-LANE	39,675.5 FT.	=	7.514 MI.
LENGTH OF ROADWAY	I-94-3(23) 105 2-LANE	3,872.9 FT.	=	0.733 MI.
LENGTH OF BRIDGES	I-94-3(23) 105 2-LANE	000.0 FT.	=	0.000 MI.
TOTAL LENGTH OF	I-94-3(23) 105 2-LANE	3,872.9 FT.	=	0.733 MI.
TOTAL LENGTH OF	I-94-3(23) 105 2-LANE & 4 LANE	43,130.4 FT.	=	8.168 MI.
TOTAL LENGTH BR'S.	I-94-3(23) 105 2-LANE & 4 LANE	418.0 FT.	=	0.079 MI.
TOTAL LENGTH OF	I-94-3(23) 105	43,548.4 FT.	=	8.247 MI.

LENGTH OF ROADWAY	I-15-2(16) 126 4-LANES	8,056.3 FT.	=	1.526 MI.
LENGTH OF PARTICIPATING BR'S.	I-15-2(16) 126 4-LANES	524.8 FT.	=	0.099 MI
TOTAL LENGTH OF	I-15-2(16) 126 4-LANES	8,581.1 FT.	=	1.625 MI.
LENGTH OF ROADWAY	IG-15-2(16) 126 4-LANES	2,426.2 FT	=	0.459 MI.
LENGTH OF PARTICIPATING BR'S.	IG-15-2(16) 126 4-LANES	798.0 FT.	=	0.151 MI
TOTAL LENGTH OF	IG-15-2(16) 126 4-LANES	3,224.2 FT.	=	0.610 MI.
TOTAL LENGTH OF ROADWAY	I-IG-15-2(16) 126 4-LANES	10,482.5 FT	=	1.985 MI.
TOTAL LENGTH OF PARTICIPATING BR'S.	I-IG-15-2(16) 126 4-LANES	1,322.8 FT.	=	0.250 MI.
TOTAL LENG. OF	I-IG-15-2(16) 126 4-LANES	11,805.5 FT.	=	2.235 MI.

LENGTH OF ROADWAY	F-77(19) 2-LANE	43,840.5 FT.	=	8.303 MI.
LENGTH OF PARTICIPATING BR'S.	F-77(19) 2-LANE	0.0 FT	=	0.000 MI.
TOTAL LENGTH OF	F-77(19) 2-LANE	43,840.5 FT	=	8.303 MI.

BENCH MARKS

MAINLINE

STATION	LOCATION	DESCRIPTION	ELEVATION
0+00	LT	BRASS CAP ON PROJ POST	3712.55'
32+57 STK	84' RT	IRON PIN	3719.74'
37+36 STK	124' LT	IRON PIN	3720.60'
66+63 STK	139' LT	IRON PIN	3721.76'
96+45 STK	88' LT	IRON PIN	3677.90'
119+28	53' LT	IRON PIN	3592.98'
140+75	140' LT	IRON PIN	3540.50'
145+18	148' LT	IRON PIN	3532.92'
169+25	154' LT	IRON PIN	3508.15'
183+50	93' LT.	IRON PIN	3502.55'
208+78	147' LT	IRON PIN	3490.06'
230+15	210' LT	IRON PIN	3495.04'
242+00	175' LT.	IRON PIN	3499.86'
250+56	127' LT	IRON PIN	3495.55'
271+40	302' LT	IRON PIN	3488.50'

SMITH ROAD

STATION	LOCATION	DESCRIPTION	ELEVATION
10+50	24' LT.	IRON PIN	3501.23'
20+02	29' RT	IRON PIN	3502.62'
30+00	32' RT	IRON PIN	3498.04'
40+00	30' RT	IRON PIN	3488.68'

FRONTAGE ROAD

STATION	LOCATION	DESCRIPTION	ELEVATION
3+42 STK	57' RT	IRON PIN	3500.70'
10+00 STK.	34' RT.	IRON PIN	3496.18'
20+00 STK.	36' RT.	IRON PIN	3487.22'
30+00 STK	36' RT.	IRON PIN	3488.46'
40+00 STK	34' RT	IRON PIN	3485.11'

C-LINE

STATION	LOCATION	DESCRIPTION	ELEVATION
0+00	123' LT	IRON PIN	3499.48'
5+67	73' LT	IRON PIN	3492.89'

COUNTY ROAD

STATION	LOCATION	DESCRIPTION	ELEVATION
50+00	27' RT.	IRON PIN	3488.53'
60+00	27' LT	IRON PIN	3394.95'
64+00	14' LT.	IRON PIN	3417.48'

BEARING SOURCE

BEARINGS SHOWN ON THESE PLANS ARE BASED ON POLARIS OBSERVATION

LEVEL DATUM SOURCE

* BENCH MARK DATA ARE BASED ON U.S.C. & G.S. B.M. M-11 LOCATED ABOUT 2 1/4 MILES NORTH ALONG THE BURLINGTON NORTHERN RAILWAY FROM THE STATION AT CONRAD AT MILEAGE 70.7 AT THE NORTH END OF A CUT, THEN ABOUT 40 FEET WEST OF THE TRACK IN LINE WITH A ROW OF POLES ELEV 3465.925 = HWY ELEV. 3465.93.

TYPICAL SECTION SHEET

General Requirements

One or more typical section sheets will show all typical sections consistent with the model on the next page. All typical sections will be orientated horizontally.

Mainline typical sections will be shown first, followed by other typical sections in the order they appear along the mainline.

All typical sections will have separate sequential whole numbers. The first typical section will be typical section number one, the second typical section will be typical section number two, and so on.

Contents

Items to be shown for each typical section are listed below:

- The typical section number
- The name of the road to which the typical section applies will be shown directly below the typical section number.
- The locations of frontage and access roads not parallel with the mainline will be shown directly below the names of frontage and access road typical sections. The locations will be referenced to mainline stationing.
- Station limits within which typical sections apply will be conspicuously shown in the upper right corner of each typical section.
- The cross-section view of the road showing the following:
    - + Grading template, including rounding at slope intersections and non-standard slope design
    - + Profile grade
    - + Surfacing templates for immediate and ultimate development
    - + Types, thicknesses and widths of surfacing materials
    - + Slopes and dimensions necessary to define the typical section. Wherever the typical section can be defined with dimensions, dimensions should be used instead of slopes.
    - + Dimensions from which cuts and fills are staked
- Quantities of gravel and bituminous materials represented by the typical section will be shown to the nearest tenth of a unit.
    - + Gravel quantities will be expressed as "area in square feet," "cubic yards per station," "tons per station" and "tons per mile."
    - + Bituminous material quantities will be expressed as "square yards per station," "tons per station," "gallons per station," "tons per mile" and "gallons per mile."
- Notes pertinent only to the specific typical section

Drafting

Typical section sheets should be drafted as follows:

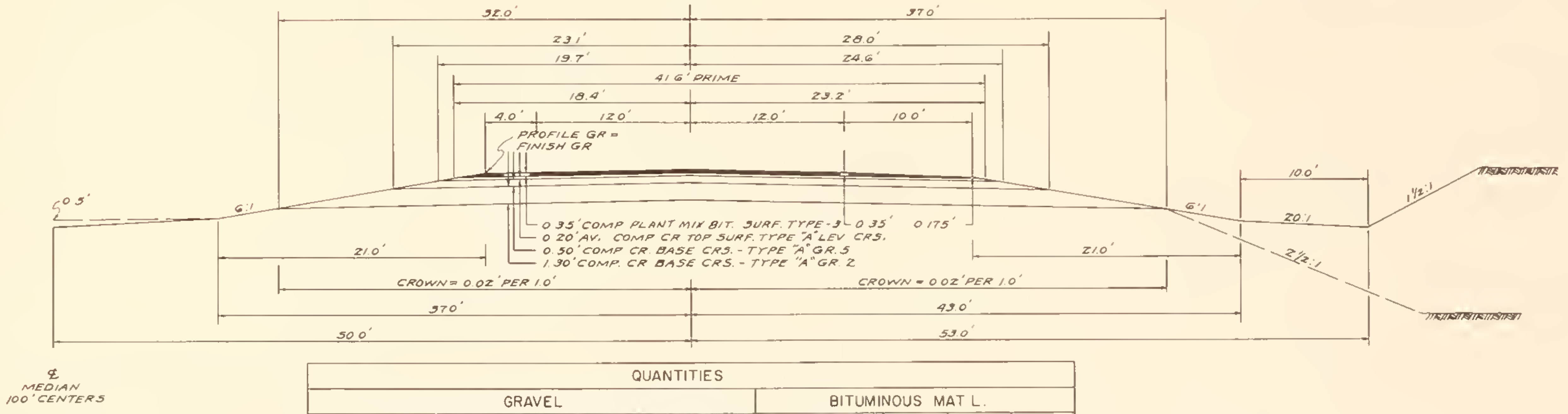
Leroy:	Typical section number and name	290 template
	Quantity Frame heading	175 template
	Quantity frame Subheadings	120 template
Handletter:	Other information	No. 1 pen

STATE	PROJECT NO	SHEET NO.
MONTANA	I-IG 15-7(13) 323	7

TYPICAL SECTION NO. 1

MAINLINE

STA. 1583+56.5 TO STA. 1505+75.3
STA 1536+83.7 TO STA 1782+18.0



QUANTITIES								
GRAVEL					BITUMINOUS MAT L.			
UNIT	PL MIX TYPE-3	CR TOP SURF. LEVELING CRS.	CR. BASE CRS.-TYPE "A" GRADE-5	CR. BASE CRS.-TYPE "A" GRADE-2	UNIT	MIX	PRIME	TACK
AREA SQ. FT	13.0	8.6	23.9	78.1	S.Y. PER STA.	411.1	462.2	462.2
C.Y. PER STA.	48.1	31.9	88.5	289.3	TONS PER STA	6.3	0.6	
TONS PER STA	*96.4	49.4	137.2	448.4	GALS. PER STA			46.2
TONS PER MI.	*5089.9	2608.3	7244.2	23675.5	TONS PER MI.	332.6	31.7	
					GALS. PER MI.			2439.4

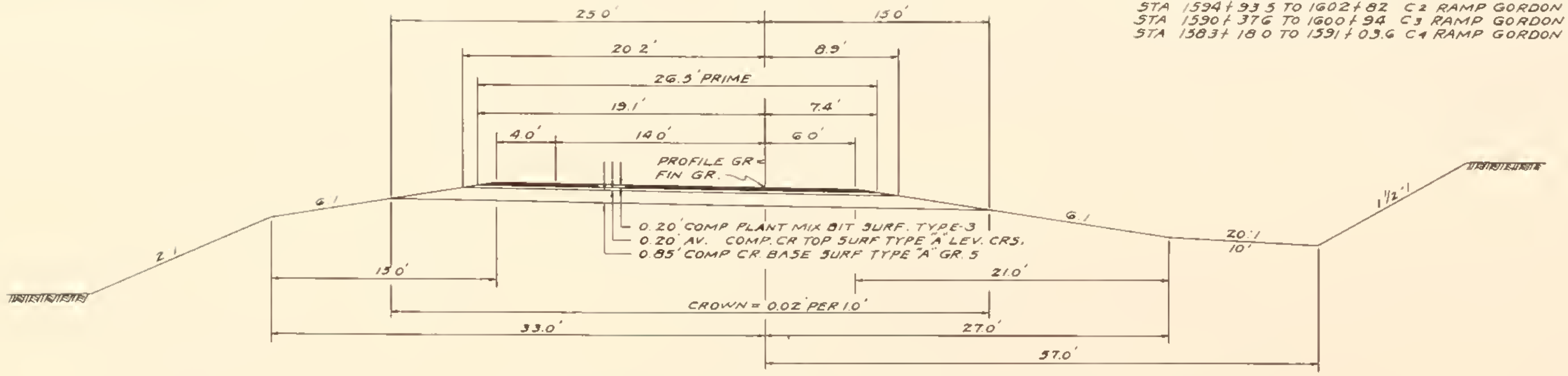
* INCLUDES WEIGHT OF PLANT MIX OIL

STA 1426 TO 1432 ½:1 LT. & RT.
STA 1543 TO 1547 1:1 LT

TYPICAL SECTION NO. 2

RAMP

STA 1585+06 TO 1593+59 C1 RAMP GORDON INTERCHANGE
STA 1594+93.5 TO 1602+82 C2 RAMP GORDON INTERCHANGE
STA 1590+37.6 TO 1600+94 C3 RAMP GORDON INTERCHANGE
STA 1583+18.0 TO 1591+03.6 C4 RAMP GORDON INTERCHANGE



QUANTITIES								
GRAVEL					BITUMINOUS MAT L.			
UNIT	PL MIX TYPE-3	CR. TOP SURF LEVELING CRS.	CR. BASE CRS.-TYPE "A" GRADE-5	CR. BASE CRS.-TYPE "A" GRADE-2	UNIT	MIX	PRIME	TACK
AREA SQ. FT.	5.1	5.6	29.4		S.Y. PER STA.	280.6	294.4	294.4
C.Y. PER STA.	18.9	20.7	108.9		TONS PER STA.	2.4	0.4	
TONS PER STA.	*37.6	32.1	168.8		GALS. PER STA.			29.4
TONS PER MI.	*1985.3	1694.9	8912.6		TONS PER MI.	126.7	21.1	
					GALS. PER MI.			1552.3

* INCLUDES WEIGHT OF PLANT MIX OIL

SUMMARY SHEETS

General Requirements

One or more summary sheets will be included in each set of contract plans. Summary sheets will show all quantities of work and materials required by the plans. No other data will be shown on summary sheets. The quantities will be in the format shown on the model sheets on the next four pages.

Stationing within each summary frame will be sequential wherever possible. To prevent unnecessary redrafting, last-minute changes will be lettered at the bottoms of frames out of sequence. At least one inch will be left at the bottoms of frames to permit last-minute additions.

A horizontal reference line will be drawn after each tenth entry of information in the summary frames.

Grading Frame

The grading frame should reflect all earthwork necessary to build the job, including major quantities for ramps, frontage roads, large channel changes, and so on.

Drafting

Summary sheets should be drafted as follows:

Leroy:	Sheet heading	425 template
	Frame titles	200 template
Handletter:	Frame lines	No. 2 pen
	Other information	No. 1 pen

STATE	PROJECT NO	SHEET NO
MONTANA	I-G 15-7(13)323	8

SUMMARY

GRADING *

STATION	CUBIC YARDS EXC UNCL	CUBIC YARDS EMB +			MI YDS HAUL	REMARKS
1250+000	372,182	380,927			229,720	MAINLINE
1379+287	376,745	376,745			61,165	MAINLINE
1427+918	380.678	880,678			122,036	MAINLINE
1491+960	530,423	272,255			18,125	MAINLINE
1626+180	329,782	330,221			307,252	MAINLINE
TOTAL	1,989,810	1,740,826			738,298	MAINLINE
0+120 1359+369	113,259	113,259			159,233	S. FRONTAGE RD "A"
1378+250	24,697	8,784			394	S. FRONTAGE RD "A" (INCL CONN TO PTW)
1257+988 1294+880	5,693	11,937			8,511	N. FRONTAGE RD "B"
0+000 7+400	1,231	2,155			1,364	CO RD SEP "A"
1574+000 1595+590	3,746	43,970			76,386	"C1" RAMP GORDON INTERCHANGE
1578+500 1591+036	2,414	21,184			33,842	"C4" RAMP GORDON INTERCHANGE
0+000 21+000	523	89,952			153,176	"C" LINE GORDON INTERCHANGE (INCL. CONN TO PTW)
1590+376 1612+000	2,768	36,805			36,326	"C3" RAMP GORDON INTERCHANGE
1594+935 1607+500	2,348	33,120			41,189	"C2" RAMP GORDON INTERCHANGE
1580+505 1597+625	1,629	18,550			32,162	"F1" FRONTAGE RD (INCL CONN TO PTW)
1595+896 1607+156	544	17,207			5,529	"F2" FRONTAGE RD (INCL CONN TO PT.W)
0+145 11+723	685	12,037			21,647	"F3" FRONTAGE RD (INCL CONN TO P.T.W)
10+000 16+713	1,006	567			0	CO RD SEP "B" (INCL CONN TO PTW)
TOTAL	160,543	409,527			569,759	
TOTAL	2,150,353	2,150,353			1,308,057	I 15-5(57) 280

* FOR DISTRIBUTION OF GRADING QUANTITIES SEE MASS DIAGRAM

SEEDING (SEE SEEDING SPECIAL PROVISIONS)

STATION FROM	STATION TO		ACRES AREA # 1	ACRES AREA # 2	POUNDS SEED	POUNDS FERT	TONS VEGETATIVE MULCH	GALS BIT. MULCH	REMARKS
2285+00	2295+00		0.9		11				CONN TO PTW
0+00	20+00		9 8		118				M L
20+00	50+00		11 9		143				M L
50+00	80+00		22 0		264				M L & MIDWAY INTERCHANGE
80+00	110+00		10 8	2 5	187	175	2 5	750	M L
110+00	140+00		10 5	0 2	131	14	0 2	60	M L
140+00	170+00		9.7		116				M L
170+00	200+00		10 4		125				M L
200+00	230+00		9 7		116				M L
230+00	260+00		11.1		133				M L
17+50	36+50		2 4	1 5	65	105	1.5	450	SMITH ROAD
0+00	30+00		3 0		36				FRONTAGE ROAD
30+00	49+00		1 3		16				FRONTAGE ROAD
260+00	290+00		32 5	1.3	421	91	1 3	390	M L & CONRAD INTERCHANGE
3+50	19+00		1 9	1 5	59	105	1.5	450	"C" LINE & CONN TO PTW
290+00	320+00		9 9		119				M L
320+00	350+00		11 4		137				M L
350+00	380+00		11.6		139				M L.
380+00	401+00		4 2	8 3	250	581	8 3	2490	M L
					259				10 % CONTINGENCY ON SEED
SUB-TOTAL			184 8	15 3	2845	1071	15 3	4590	I-15-7 (13) 323
401+00	407+00		1.4	1 1	43	77	1 1	330	M L
					4				10 % CONTINGENCY ON SEED
TOTAL									IG-15-7(13) 323
407+00	410+00		0 5	0 5	18	35	0.5	150	M L
410+00	440+00		9 4	5 7	250	399	5 7	1710	M L
440+00	470+00		17.3		208				M.L & REST AREAS
470+00	474+77		1 7		20				M L
44+73.5	80+50		0 5	0 4	16	28	0 4	120	DRY FORK MARIAS
					51				10 % CONTINGENCY ON SEED
SUB-TOTAL			29 4	6 6	563	462	6 6	1980	I-15-7(13)323
TOTAL			214.2	21.9	3408	1533	21 9	6570	I-15-7(13)323
TOTAL			1.4	1.1	47	77	1 1	330	IG-15-7(13)323
TOTAL			215 8	23 0	3455	1610	23 0	6900	I-IG-15-7 (13) 323

ADDITIONAL EXCAVATION

STATION FROM	STATION TO		CU. YDS ADD EXC	REMARKS
390+00	707+164		69,828	TOPSOIL REPLACEMENT + 20%
395+00			85	MEDIAN U-TURN
401+00			10	ROAD APPROACH LEFT FRONT ROAD
423+90E.B.	424+18E.B		870	REMOVE - COUNTY ROAD
429+49	435+73		280	RAMP "B1" CHANNEL CHANGE
469+65E B	479+52E B		973	IRRIGATION DITCH
516+96			2	DITCH BLOCK LT W B
517+00			25	OUTLET DITCH RT E B
527+32	528+41		39	OUTLET DITCH
528+97	529+69E B		57	DRAIN DITCH
529+69	535+20		2,800	MEDIAN DITCH
17+31	32+27		38,269	DETOUR ROAD EMBANKMENT REMOVAL
557+40E B	562+50 E B		500	SUBGRADE TRANSITION E B
564+80	565+30		194	DRAIN DITCH LT
572+65			53	OUTLET DITCH RT
579+45			19	OUTLET DITCH RAMP G4
579+52			8	DITCH BLOCK
TOTAL			114,012	I 90-3 (23) 166

TOPSOIL

STATION FROM	STATION TO	CUBIC YARDS LT	CUBIC YARDS MEDIAN	CUBIC YARDS RT	REMARKS
390+00	540+00	10,170	7,582	6,868	
540+00	604+00	8,104	3,104	6,972	
604+00	707+164	4,432	7,262	3,696	
TOTAL		22,706	17,948	17,536	I 90-3(23) 166

NOTE INCLUDES REST AREA RAMPS (3190 C.Y.) SEE REST AREA SUMMARY FOR FACILITY AREAS

STATE	PROJECT NO.	SHEET NO
MONTANA	190-3(23) 280	9

SUMMARY

CULVERTS

STATION	L. F. NEW C.S.P.																L. F. NEW S.S.P.P.C.		L. F. NEW 24" C.S.P. IRR.	T-SECTIONS	LENGTH OF RISER	MEDIAN INLET COVER		ELBOWS		HEIGHT OF COVER IN FEET	SKEW ANGLE	END SECTION		C.Y. BED MATL.	C.Y. CULV. EXC.	REMARKS
	24"				30"				36"						48"		96"					TYPE										
	0.064		0.109		0.064		0.109	0.188	0.079	0.109 ELONG	0.109	0.138	0.168		0.109 ELONG	0.138	0.109		0.064"			1	2	NO.	ANGLE			LT	RT			
565+50																	252									14	50° RT	*	*	321	450	MED ℄ DRAIN
565+50																	66									2		⊕	⊕	39	15	FR. RD. DRAIN
570+18	8				264															30"x24"	8	1				17		F.E.T.S.	F.E.T.S.		15	MED. ℄ DRAIN
577+00	106																						1			10			F.E.T.S.		75	E B MED. DRAIN
585+00	240																			24"x24"	0	1		1	3°30'	13		F.E.T.S.			10	W.B. DRAIN
600+65	198																									24	30° RT.	SQ.	SQ.		75	W.B. DRAIN
605+05	134																									12	25° RT.	SQ.	SQ.		60	W.B. DRAIN
612+51			292																							35	10° LT.	F.E.T.S.	SQ.		25	W.B. DRAIN
615+50															292											42	30° RT.	SQ.	SQ		25	W.B. DRAIN
621+65	150																									14		F.E.T.S.	F.E.T.S.		20	W.B. DRAIN
641+43	174																									15	35° RT	SQ.	SQ.		5	W.B. DRAIN
647+58	138																									10	15° LT.	F.E.T.S.	F.E.T.S.		5	W.B. DRAIN
639+60	120																									9		F.E.T.S.	F.E.T.S.		15	W.B DRAIN
599+48	182																									11	15° RT	F.E.T.S.	F.E.T.S.		15	E.B. DRAIN
604+69	184																									22		F.E.T.S.	SQ.		20	E.B. DRAIN
608+05																278										42	27° RT.	SQ.	SQ.		375	E.B. DRAIN
628+62	180																							2	25°	6		F.E.T.S.	SQ.		45	E B. DRAIN
655+22	196																							2	18°	6		F.E.T.S.	SQ.		105	E.B. DRAIN
641+45	176																									15	20° RT.	SQ.	SQ.		15	E.B. DRAIN
643+68	180																							2	22°	13		F.E.T.S.	SQ.		100	E.B. DRAIN
646+03	208																							2	16°	7	20° RT.	F.E.T.S.	SQ.		45	E.B. DRAIN
648+68	174																									11	25° LT.	SQ.	SQ.		35	E.B. DRAIN
651+59	12									400										36"x24"	12	1				31	25° RT.	SQ.	SQ.		535	W.B. DRAIN
674+78	220																									7		F.E.T.S.	F.E.T.S.		155	MED ℄ DRAIN
680+89	104																						1			5		F.E.T.S.			30	MED. ℄ DRAIN
683+65					284																					12	30°30' LT.	SQ.	SQ.		65	MED. ℄ DRAIN
694+66													558							36"x24"	0	1				27	15° RT.	F.E.T.S.	F.E.T.S.		560	MED. ℄ DRAIN
46+75	52																									2		F.E.T.S.	F.E.T.S.		15	X-RD. DRAIN
48+50	62																									5		F.E.T.S.	F.E.T.S.		15	X-RD. DRAIN
697+73	50																									2		F.E.T.S.	F.E.T.S.		15	RAMP "B" DRAIN
697+82	60																									3		F.E.T.S.	F.E.T.S.		30	RAMP "C" DRAIN
697+85	304																									22		SQ.	SQ.		650	MED. ℄ DRAIN
710+00	322																			24"x24"	4	1				13		F.E.T.S.	F.E.T.S.		15	MED. ℄ DRAIN
730+64									546																	22	56° RT	SQ.	SQ		510	MED ℄ DRAIN
752+00	120																						1			7		F.E.T.S.			20	MED. ℄ MED. DRAIN
742+19												390														26	37° RT.	SQ.	SQ		150	MED. ℄ DRAIN
746+00	110																						1			6		F.E.T.S.			60	MED. ℄ MED. DRAIN
749+33					352																					16	50° LT.	SQ.	SQ.		50	MED. ℄ DRAIN
754+52	332																									12	36° LT.	SQ.	SQ.		115	MED. ℄ DRAIN
766+35	290																									8		F.E.T.S.	F.E.T.S.		5	MED. ℄ DRAIN
771+17	20						342													30"x24"	20	1				27	25° LT.	SQ.	SQ.		215	W.B. DRAIN
827+58								216																		35	15° LT.	SQ.	SQ.		5	W.B. DRAIN
845+43											176															23	15° RT.	SQ.	F.E.T.S.		5	W.B. DRAIN
847+50																			230												25	MED. ℄ IRRIGATION
	4826		232		900		342	216	546	400	176	390	558		292	278	318		230	–	–	6	4	9		–	–	–	–	380	4795	190-3(23)280

*SKEW BEVEL 2:1

⊕ ENDS - STEP BEVEL 2:1

EMBANKMENT PROTECTORS

STATION	LINEAR FEET 12" C.S.P. (THICK. 0.064")		C.Y. TYPE 3 BANK PROT	REMARKS
	LT.	RT.		
561+80	16		1.5	LT. OF STATION - W.B.
566+04		64	–	θ = 30° E.B.
580+68		62	1.5	θ = 30° ℄ MED.
569+50		100	1.5	θ = 30° E.B.
576+11	60		2.5	θ = 30° RAMP G₁
582+25	94		1.5	θ = 15° W.B.
661+50	70		1.5	θ = 15° W.B.
662+35	28		1.5	θ = 15° E.B.
TOTAL	268	226	11.5	190-3(23)166

CULVERTS - ALTERNATE

STATION	ALTERNATE "A"							ALTERNATE "B"							ALTERNATE "C"						HEIGHT OF COVER IN FEET	SKEW ANGLE	BASIC BID			REMARKS
	L. F. NEW C.S.P.							L. F. NEW R.C.P.							L. F. NEW C.A.P.								END SECTION		C.Y. CULV. EXC	
	24"		30"		48"			24"		30"		48"			24"		30"		48"							
	THICKNESS							CLASS							THICKNESS								LT	RT		
	0.064		0.084		0.079			2		2		2			0.078		0.078		0.105							
570+18			36							36							36				2		F.E.T.S.	F.E.T.S.	10	FR RD. RT.
60+75					78							78							78		2	30° LT.	SQ.	SQ.	35	CD. RD. EXT.
12+00	60							60							60						2		SQ.	SQ.	10	SD. DOZER TRAIL
18+93	60							60							60						2		SQ.	SQ.	10	SD. DOZER TRAIL
22+00	60							60							60						2		SQ.	SQ.	10	SD. DOZER TRAIL
TOTAL	180		36		78			180		36		78			180		36		78		–				75	190-3(23)280

STATE	PROJECT NO	SHEET NO
MONTANA	I 90-3(23)280	10

SUMMARY

SURFACING

STATION		LINEAR FEET				FOR	TONS PLANT MIX TYPE 3	TONS AGGREGATE					BITUMINOUS MATERIAL			REMARKS
								CRUSHED TOP SURFACING		CRUSHED BASE COURSE			TONS		GALLONS	
FROM	TO	GROSS	NET	+	−			TYPE "A" GR. 2	TYPE "B" GR. 3	TYPE "A" GR. 5	TYPE "A" GR. 2		PLANT MIX 120-150	PRIME MC-70	TACK SS-1	
1250+00.0																
1294+38.5	1295+61.5				123.0	NEW DUAL PREST. CONC. O'PASS										
	1335+09.8	10509.8	10386.8				19949	10223		28392	92790		1303.7	124.2	9560	TYPICAL SECTION NO. 1
1335+09.8	1383+56.5	2846.7	2846.7				5463	2778		7635	24547		353.0	34.2	2610	TYPICAL SECTION NO. 2
1383+56.5																
1388+84.4	1389+09.9				25.5	PROJECT EQUATION										
	1505+73.3	12218.8	12193.3				23509	12047		33458	109350		1536.4	146.3	11267	TYPICAL SECTION NO. 1
1505+73.3	1536+83.7	3108.4	3108.4				5965	3034		8337	26804		385.4	37.3	2850	TYPICAL SECTIUN NO. 2
1536+83.7																
1537+78.8	1537+35.1			43.7		PROJECT EQUATION										
1718+83.7	1720+32.7				143.0	NEW DUAL PREST. CONC. O'PASS										
	1782+18.0	24534.3	24435.0				47034	24102		66940	218774		3073.8	292.7	22541	TYPICAL SECTION NO. 1
						ADDITIONAL SURFACING	7048	4212	3152	18200			458.4	65.4		
TOTAL		53218.0	52970.2	43.7	291.5		108968	56396	3152	162962	472265		7110.7	700.1	48828	I 90-3(23) 280

ADDITIONAL SURFACING (INCLUDED IN SURFACING SUMMARY)

STATION		LINEAR FEET		FOR	TONS PLANT MIX TYPE 3	TONS AGGREGATE					BITUMINOUS MATERIAL				REMARKS
						CRUSHED TOP SURF.		CR BASE COURSE			TONS		GALLONS		
FROM	TO	GROSS	NET			TYPE "A" GR. 2	TYPE "B" GR 3	TYPE "A" GR. 5	TYPE "A" GR 2		PLANT MIX 120-150	PRIME MC-70	TACK SS-1		
41+63.2	60+10.0			RECONDITIONING FR. ROAD	38						2.47				SEE SPECIAL PROVISIONS
390+00.0	428+79.7	3879.7	3879.7	FRONTAGE ROAD			3104								TYPICAL SECTION NO. 11
413+45.9	448+02.2	3452.2	3452.2	RAMP B1	1722	1497		6854			110.23	18.37			TYP SEC. NO 15(INCLS TAPER & PARKING)
520+00.0	556+00.0	3600.0	3600.0	RAMP B2	1822	1584		7231			116.64	10.44			TYP. SEC. NO. 16(INCLS TAPER & PARKING)
481+00.0		154.0	154.0	PAVT FOR VEH U'PASS	19	9		40			1.12	0.18			
475+32.9	507+00.0	3167.1	3167.1	DETOUR ROAD	1197	1048		3810			79.18	12.67			TYPICAL SECTION NO. 12
500+70.0	558+00.0	5730.0	5730.0	DETOUR ROAD	2166	—		—			143.25	22.92			TYPICAL SECTION NO 12 PLANT MIX ONLY
				ROAD APPROACHES	84	74	48	265			5.48	0.86			
TOTAL		19983.0	19983.0		7048	4212	3152	18200			458.37	65.44			I 90-3(23) 280

SUMMARY

STATE	PROJECT NO	SHEET NO.
MONTANA	I 90-3(23)280	11

CATTLE GUARDS

STATION	24'		REMARKS
42+00	1		FRONTAGE ROAD
579+00	1		RAMP C4
580+76	1		RAMP C3
580+88	1		RAMP C1
585+55	1		RAMP C2
92+60	1		FRONTAGE ROAD
44+88	1		FRONTAGE ROAD
55+00	1		FRONTAGE ROAD
TOTAL	8		I 90-3(23)280

METAL GUARD RAIL & MEDIAN RAIL (WOOD POSTS)

STATION		LINEAR FEET				UNITS BRIDGE APPROACH SECTION TYPE - I		REMARKS
		METAL GUARD RAIL		METAL * MEDIAN RAIL				
FROM	TO	LT	RT			LT	RT.	
468+00	513+50			4550				MEDIAN - INCLUDES 2 ROUNDED END SECTIONS
558+39.0	566+890		825.0				1	EASTBOUND INCL TERM SEC. NO 1 OUTSIDE SHOULDER
565+301	566+19.5	175.0				1		EASTBOUND INCL TERM SEC. NO 1 INSIDE SHOULDER
568+32	577+32		875.0				1	EASTBOUND INCL TERM. SEC. NO 2 OUTSIDE SHOULDER
562+14	567+095	475.0				1		WESTBOUND INCL TERM SEC. NO 2 OUTSIDE SHOULDER
569+82	578+19.5	812.5				1		RAMP G1 INCL TERM SEC. NO 1 OUTSIDE SHOULDER
569+33	571+330		175.0				1	WESTBOUND INCL TERM. SEC. NO 1 INSIDE SHOULDER
578+232	579+357		87.5				1	EASTBOUND INCL TERM SEC. NO 1 OUTSIDE SHOULDER
577+459	579+45.9	175.0				1		EASTBOUND INCL TERM SEC. NO.1 INSIDE SHOULDER
578+413	579+663	100.0				1		WESTBOUND INCL TERM SEC. NO 2 OUTSIDE SHOULDER
581+094	582+219	87.5				1		WESTBOUND INCL TERM SEC. NO 1 OUTSIDE SHOULDER
580+99.2	582+99.2		175.0				1	WESTBOUND INCL TERM SEC. NO 1 INSIDE SHOULDER
580+638	582+138		125.0				1	EASTBOUND INCL TERM SEC. NO 1 OUTSIDE SHOULDER
581+12.5	589+750		862.5					RAMP G 3 INCL TERM SEC. NO.1 & 2 OUTSIDE SHOULDER
TOTAL		1825.0	3125.0	4550		6	6	I 90-3(23)280

* LENGTH INCLUDES DOUBLE RAIL INSTALLATION

CONCRETE APPROACH SLABS

STATION		S. Y CONC		REMARKS
FROM	TO	TYPE "B"	TYPE "D"	
566+844	566+044	91.7		EASTBOUND
566+65.5	566+85.5	96.4		WESTBOUND
568+544	568+744	91.7		EASTBOUND
569+50.5	569+70.5	108.9		WESTBOUND
579+216	579+416	93.4		EASTBOUND
579+404	579+60.4	93.4		WESTBOUND
580+69.7	580+897	93.4		EASTBOUND
581+035	581+23.5	93.4		WESTBOUND
661+41.0	661+610		92.5	WESTBOUND
662+30.2	662+50.2		92.5	EASTBOUND
662+39.0	662+59.0		92.5	WESTBOUND
663+28.2	663+48.2		92.5	EASTBOUND
TOTAL		762.3	370.0	I 90-3(23)280

MONUMENTS & MARKERS

STATION		NEW CONC PROJECT MARKERS	NEW CONC R/W MONUMENTS	RESET CONC R/W MONUMENTS	STATION MARKERS	REMARKS
FROM	TO					
390+00	707+164	1	71	16	35	
TOTAL		1	71	16	35	I 90-3(23)280

* 4" CONCRETE SIDEWALK

STATION		SQUARE YARDS	REMARKS
FROM	TO		
430+75	433+70	167	W.B REST AREA CAR PARKING
535+30	538+30	167	E.B. REST AREA CAR PARKING
		334	I 90-3(23)280

* 5' WIDE

CONCRETE CURB & GUTTER

STATION		LINEAR FEET	REMARKS
FROM	TO		
431+00	434+00	360	W.B REST AREA CAR PARKING
433+00	435+50	500	W.B REST AREA CHANNELIZATION ISLAND
535+00	538+00	380	E.B REST AREA CAR PARKING
531+60	534+65	660	E.B REST AREA CHANNELIZATION ISLAND
TOTAL		1900	I 90-3(23)280

MISC. TO BE REMOVED BY CONTRACTOR

464+80.0 ℄ MED	2 WOOD HEADGATES 2'X 3 2'	77' LT
50+15	CORRAL (WARM SPRGS CR RD)	RT
652+85.0 TO 657+80.0	W B WOOD & METAL IRR TROUGHS	LT & RT
659+00	15'X 20' WOOD BRIDGE	20' LT

MOTOR GRADER HOURS

20-HOURS FOR RECONDITIONING AND CLEANING OF OLD HIGHWAY THAT IS TO BE USED AS FRONTAGE ROAD.

40-HOURS - CONTOUR GRADING PHOSPHATE INTERCHANGE.

DETAIL SHEETS

General Requirements

Detail sheets to be included in contract plans are those showing:

- Nonstandard items
- Mass diagrams

Requirements for each type of detail are presented on the following pages.

Nonstandard Items

General Requirements

One or more detail sheets will be used to show details of nonstandard items. Detail sheets should be used for those items which require more specific information than can be placed on either the plan or the profile views of plan and profile sheets. For example, hydraulic details may require detail sheets.

Each detail will be clearly labeled in the title box in the lower right corner of the space allotted to the detail. The title box will show the name of the detail, the station where is applies and the scale to which it is drawn.

The initials of the persons who drew and checked the detail and the dates of drawing and checking will appear in the lower left corner of the space allotted to the detail.

Drafting

Detail sheets showing nonstandard items should be drafted as follows:

Leroy:	Sheet heading (DETAILS) Title box information	425 template 140 template
Handletter:	Other information	No. 1 pen

Mass Diagram

General Requirements

A single-sheet mass diagram will be included in contract plans for earthwork projects. The mass diagram will provide a capsule view of the earth quantities and how they are moved.

Balance points, cubic yards of earth and haul quantities will be shown.

The scale will be that necessary to place the mass diagram on one sheet. Where practicable, the mass diagram should be continuous, with no breaks.

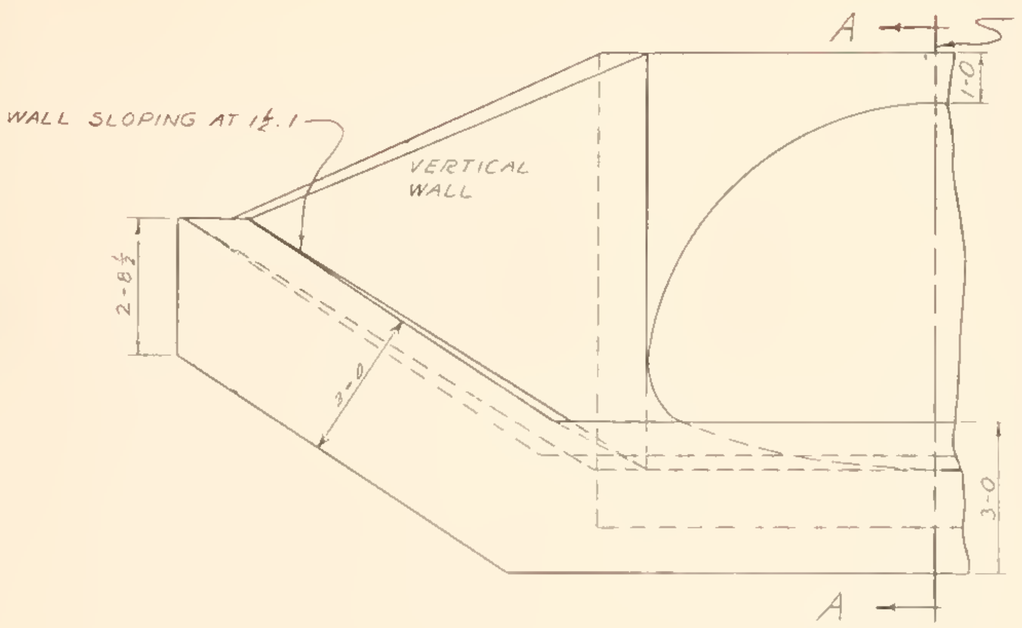
Drafting

Mass diagrams will be drafted as follows:

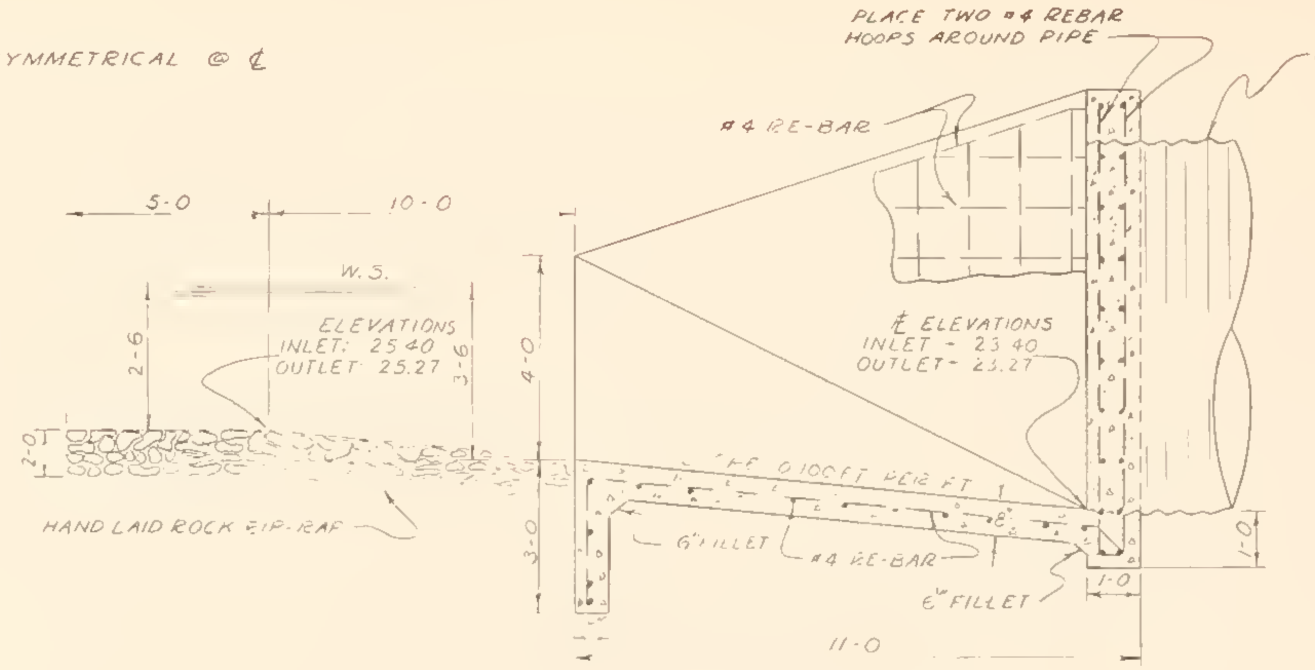
Leroy:	Sheet heading (MASS DIAGRAM)	425 template
Handletter:	Other information	No. 1 pen

DETAIL

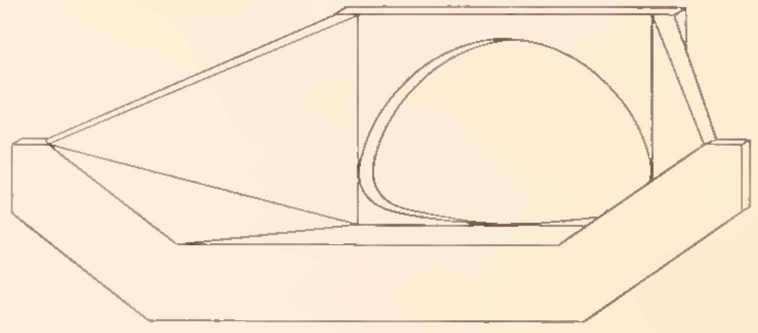
STATE	PROJECT NO.	SHEET NO.
MONTANA	I-10-15-7(15)323	12



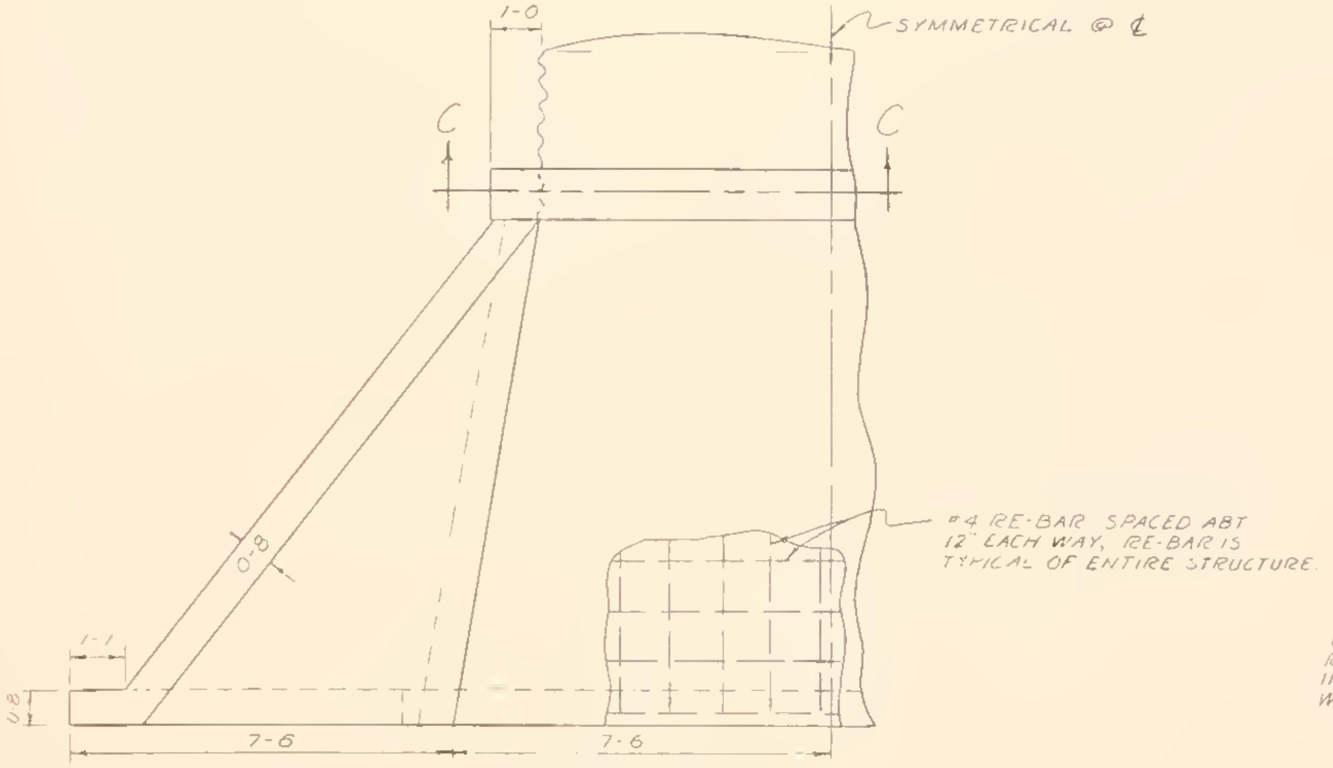
ELEVATION
SCALE: ½"=1'



SECTION A-A
SCALE ½"=1'

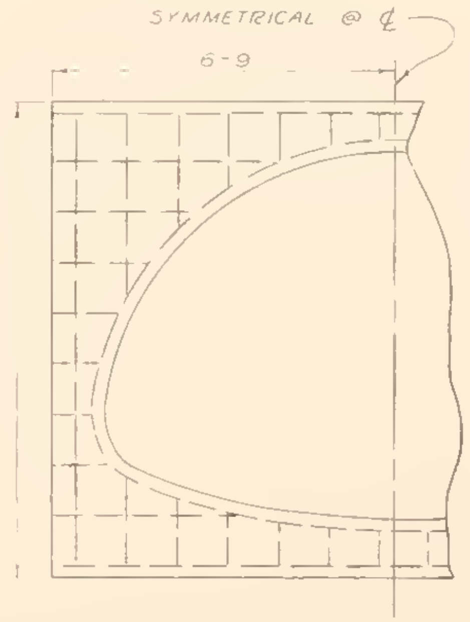


ORTHOGRAPHIC PROJECTION
SCALE: ¼"=1'


1-0
SYMMETRICAL @ ℄
C
C
#4 RE-BAR SPACED ABT 12" EACH WAY, RE-BAR IS TYPICAL OF ENTIRE STRUCTURE.
0-8
1-1
0-8
7-6
7-6

PLAN VIEW
SCALE: ½"=1'

NOTE: LAP ALL RE-BAR 1-6 MIN. INTO FLOOR AND WALLS.



SECTION C-C
SCALE ½"=1'

SPECIFICATIONS Montana State Highway Commission Standard Specifications for road and bridge construction adopted March 1, 1966 and any amendments thereto, and special provisions shall govern unless otherwise noted.
CONCRETE All concrete shall be class "DD" unless otherwise noted. Chamfer all exposed edges ¾" inches. An air entraining agent shall be added to all Concrete.
REINFORCING STEEL: All reinforcing bars shall conform to A-15 intermediate grade billet steel. Deformation shall conform to AASHO specifications M137, except as otherwise approved. Slab bars shall be supported on precast concrete blocks placed sufficiently close together to maintain bars in the proper position. Lap 18 inches when splicing reinforcing steel.
CONSTRUCTION JOINTS Construction joints shall be made only at locations shown on plans or as approved by the engineer. Adequate keys shall be provided at all construction joints as noted on the plans or determined by the engineer.

⊗ QUANTITIES

STRUCTURE	CONCRETE CU. YD.	* REINFORCING STEEL LBS.	HAND LAID ROCK RIP-RAP CU. YD.
INLET	11.5	833.28	36.0
OUTLET	11.5	833.28	36.0
TOTAL	23.0	1666.56	72.0

⊗ QUANTITIES INCL IN IRRIGATION STRUCTURE FRAME SHT NO. 11
* INCL. IN UNIT PRICE BID FOR CL "DD" CONC.

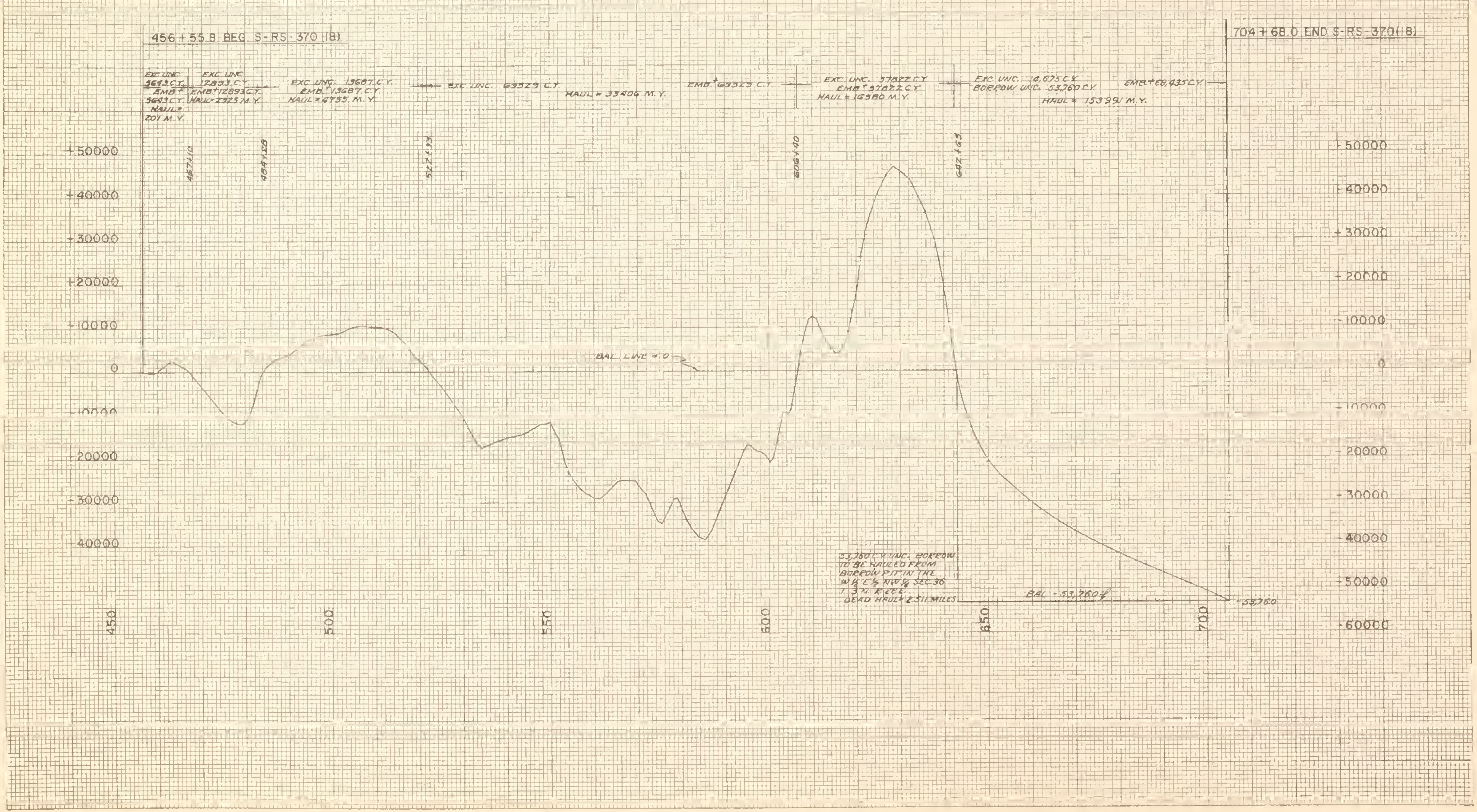
DRAWN	R.R.H.	4-9-70
CHECKED	J.C.B.	4-10-70

INLET & OUTLET STRUCTURE
STA 149+00

SCALE AS NOTED

MASS DIAGRAM

STATE	PROJECT NO	SHEET NO
MONTANA	I IG 15-7(13)323	15



FINAL SURVEY
NOTE BOOK NO.
SURVEYED
PLOTTED
TEMPLATE
AREAS
AREAS CHECKED
BY
DATE

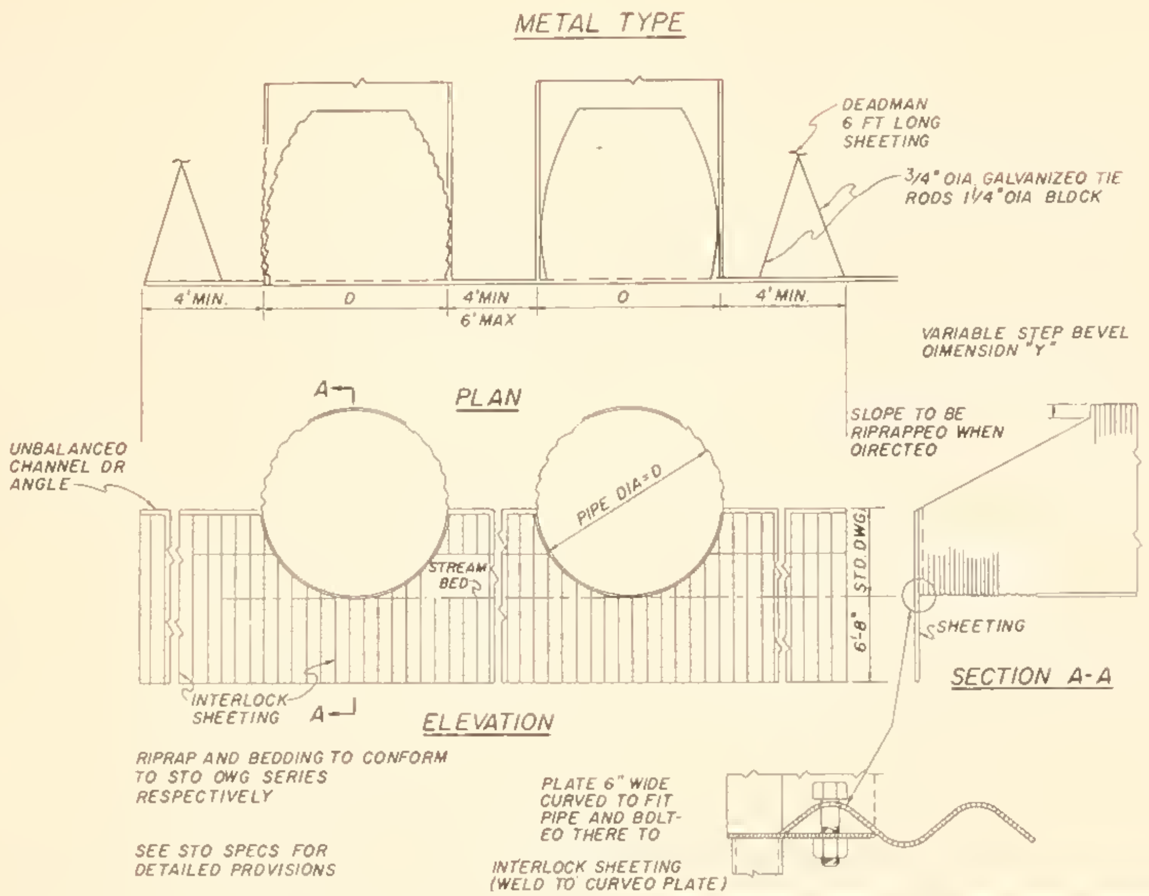
ORIGINAL SURVEY
NOTE BOOK NO.
SURVEYED
PLOTTED
TEMPLATE
AREAS
AREAS CHECKED

STANDARD DRAWINGS

All standard drawings applicable to the project will be included in the contract plans.

Where two standard drawings are included on the same sheet, as shown on the next page, and only one applies to the project, the other standard drawing will be stamped "NOT APPLICABLE."

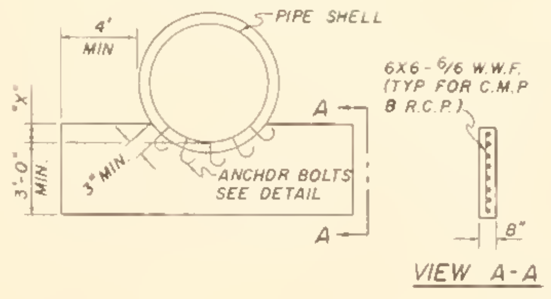
METAL TYPE


DEADMAN
6 FT LONG
SHEETING
3/4" DIA GALVANIZED TIE RODS 1 1/4" DIA BLOCK
4' MIN.
D
4' MIN
6' MAX
D
4' MIN.
VARIABLE STEP BEVEL DIMENSION "Y"
A
PLAN
UNBALANCED CHANNEL OR ANGLE
PIPE DIA = D
STREAM BED
STD DWG.
6'-8"
SLOPE TO BE RIPRAPPED WHEN DIRECTED
SHEETING
SECTION A-A
INTERLOCK SHEETING
A
ELEVATION
PLATE 6" WIDE CURVED TO FIT PIPE AND BOLTED THERE TO
INTERLOCK SHEETING (WELD TO CURVED PLATE)

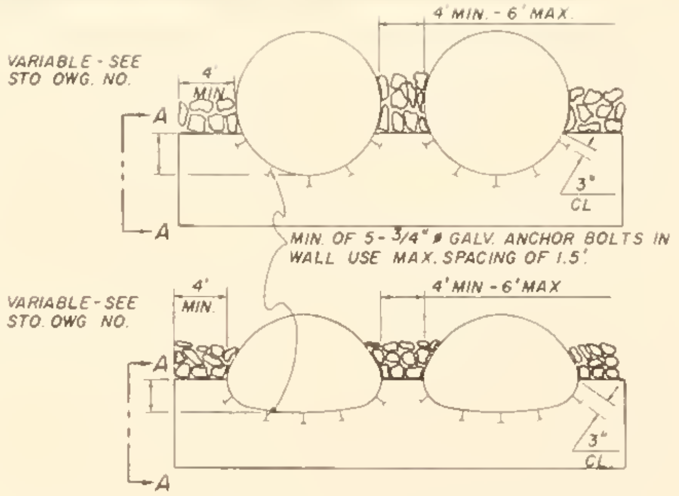
RIPRAP AND BEDDING TO CONFORM TO STD DWG SERIES RESPECTIVELY

SEE STD SPECS FOR DETAILED PROVISIONS

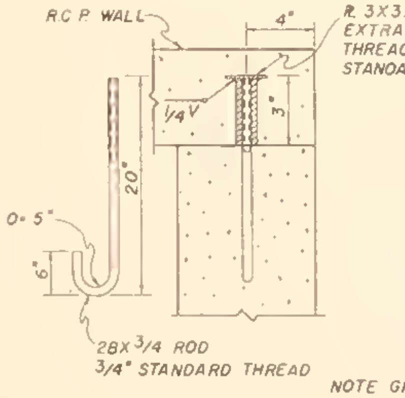
CONCRETE TYPE



VIEW A-A


VARIABLE - SEE STD DWG. NO.
4' MIN
4' MIN. - 6' MAX.
A
A
3"
CL
MIN. OF 5 - 3/4" ϕ GALV. ANCHOR BOLTS IN WALL USE MAX. SPACING OF 1.5'
VARIABLE - SEE STD DWG NO.
4' MIN
4' MIN - 6' MAX
A
A
3"
CL

CUTOFF WALL FOR METAL CULVERT


R.C.P. WALL
4"
R 3X3X1/4 WELD TO DBL EXTRA STRONG PIPE THREADED INSIDE WITH STANDARD 3/4" THREAD
1/4"
3"
20"
D = 5"
6"
2BX 3/4 ROD
3/4" STANDARD THREAD

DETAIL
ANCHOR BOLT

	"X" IN FT.			N
DIA	1 1/2:1	2:1	2 1/2:1	N
48"	.4	9	9	4
54"	.4	9	9	4
60"	.4	.9	.9	4
66"	6	1.2	1.1	4
72"	9	1.1	1.0	5
78"	1.1	1.7	1.2	5
84"	1.4	1.4	1.1	6

N = NUMBER OF ANCHOR BOLTS

NOTE GREASE THREAD TO KEEP MOISTURE OUT

NOTES: DIMENSIONS BETWEEN MULTIPLE S.P.P.C. AND S.P.P.A.C. SHALL BE A MAX OF 6 FT AND A MINIMUM OF 4 FT. UNLESS OTHERWISE NOTED.

CONCRETE - CL "OD" OR EQUAL REINFORCING MAT'L TO BE INCLUDED IN UNIT PRICE BID PER CU. YD CONC ANCHOR BOLTS TO BE INCLUDED IN THE UNIT PRICE BID PER LIN FT OF PIPE.

SEE STD DWG SERIES NO. 54 FOR BACKFILL UNDER CULVERTS

SEE STD DWG SERIES NO 50 - FOR RIPRAP

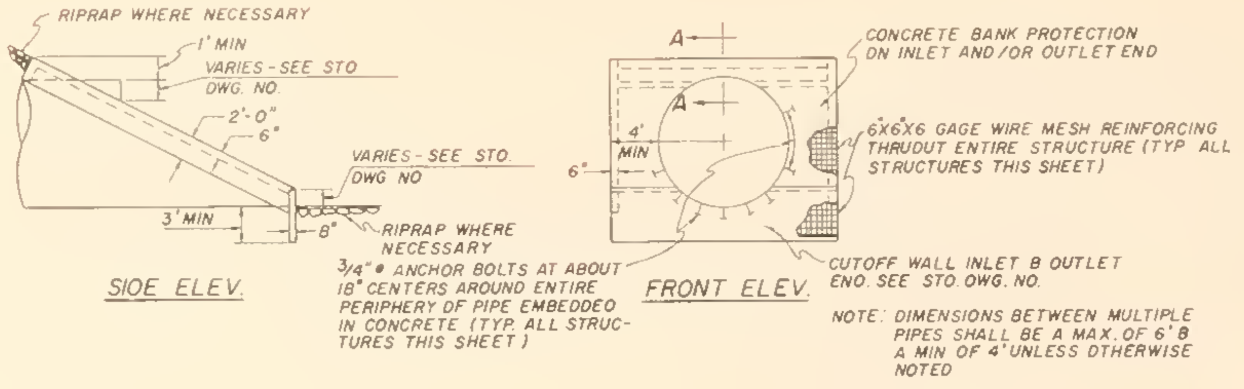
STANDARD DRAWING
REFERENCE: DWG. NO.
STANDARD SPEC
SECTION

CUTOFF WALLS
FOR CULVERTS

REVISED			
EFFECTIVE			

APPROVED
STATE HIGHWAY ENGINEER

STATE	PROJECT NO	SHEET NO.
MONTANA	I IG 15-7(13)323	13

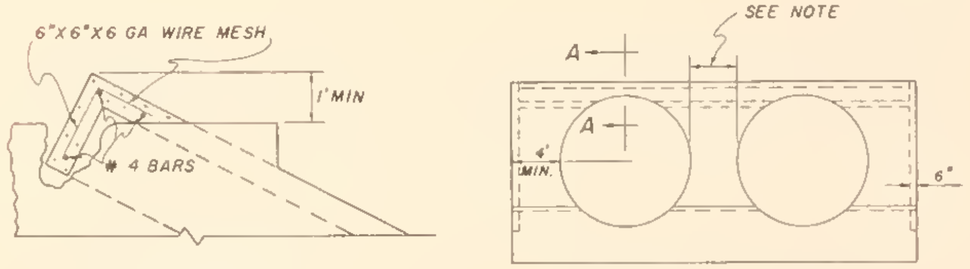

RIPRAP WHERE NECESSARY
1' MIN
VARIES - SEE STD DWG. NO.
2'-0"
6"
VARIES - SEE STD. DWG NO
3' MIN
8"
RIPRAP WHERE NECESSARY
A
A
4' MIN
6"
CONCRETE BANK PROTECTION ON INLET AND/OR OUTLET END
6X6X6 GAGE WIRE MESH REINFORCING THRUOUT ENTIRE STRUCTURE (TYP ALL STRUCTURES THIS SHEET)
CUTOFF WALL INLET & OUTLET END. SEE STD. DWG. NO.

3/4" ϕ ANCHOR BOLTS AT ABOUT 18" CENTERS AROUND ENTIRE PERIPHERY OF PIPE EMBEDDED IN CONCRETE (TYP. ALL STRUCTURES THIS SHEET)

SIDE ELEV.

FRONT ELEV.

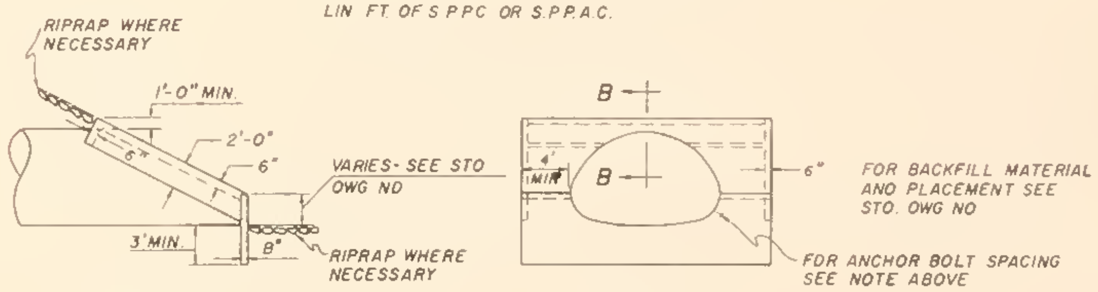
NOTE: DIMENSIONS BETWEEN MULTIPLE PIPES SHALL BE A MAX. OF 6' & A MIN OF 4' UNLESS OTHERWISE NOTED



SECTION A-A

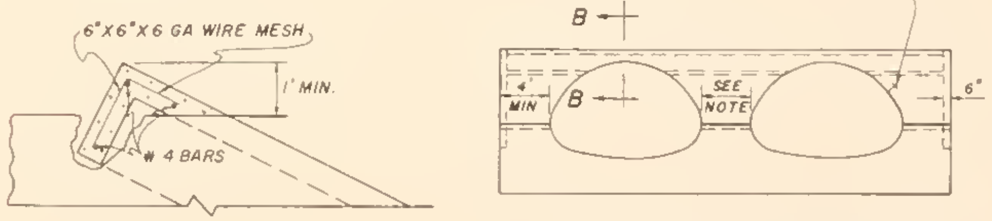
FRONT ELEVATION MULTIPLE PIPES

CL "OD" CONCRETE OR EQUAL, REINFORCING MAT'L, TO BE INCLUDED IN THE UNIT PRICE BID PER CU. YDS OF CONCRETE. ANCHOR BOLTS TO BE INCLUDED IN THE UNIT PRICE BID PER LIN FT OF S.P.P.C. OR S.P.P.A.C.



SIDE ELEV.

FRONT ELEV.



SECTION B-B

FRONT ELEVATION MULTIPLE PIPES

* THIS CONCRETE COLLAR IS TO HELP PREVENT METAL FAILURE OF CULVERT EDGE ESPECIALLY WHERE HIGH HEADWATERS ARE PREVALENT.

STANDARD DRAWING
REFERENCE: DWG. NO.
STANDARD SPEC
SECTION

CONCRETE EDGE PROTECTION
FOR STRUCTURAL PLATE PIPE
CULVERT & FOR STRUCTURAL
PLATE PIPE ARCH CULVERT *

REVISED			
EFFECTIVE			

APPROVED:
STATE HIGHWAY ENGINEER

PLAN AND PROFILE SHEETS

General Requirements

Plan and profile sheets will show the horizontal and vertical alignments and depict the construction items and the topography necessary for construction.

Sequence of Sheets

Mainline plan and profile sheets will be shown first in the order of increasing stationing. The continuous stationing of mainline plan and profile sheets will not be interrupted by special sheets showing features on or near the mainline.

Special plan and profile sheets showing connections, interchanges, intersections, detour roads, frontage roads, railroads, and so on, will appear after the mainline plan and profile sheets in the order they appear along the mainline.

Special plan and profile sheets, as required for each feature, will be arranged in this order:

1. Plan view of geometric layout
2. Plan and profile
3. Supplemental profiles
4. Contour grading plan

Labeling Special Sheets

Special plan and profile sheets will be clearly labeled on their right sides so that any plan user can readily determine what special feature is shown.

Orientation of Notes

All notes and dimensions will be written horizontally from left to right, with the following exceptions:

- Plan Views

  Pipe installation notes, ten stationing, equations and right-of-way breaks will be written vertically.

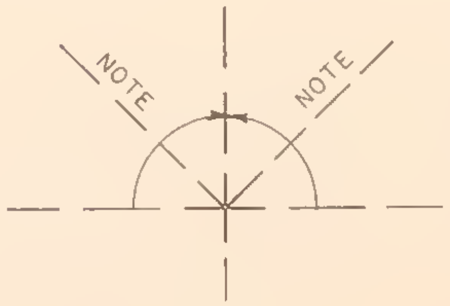
- Profile Views

  Equations will be written diagonally. Full stations and elevations of vertical curve P.I.'s will be written vertically.

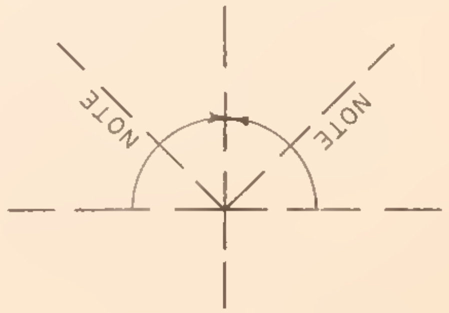
- Special Considerations

  Where limited space for notes and dimensions makes horizontal placement detrimental to the readability of the plans, they may be placed vertically.

No notes or dimensions will be written from right to left in an inverted position.



CORRECT



WRONG

STATE	PROJECT NO.	SHEET NO.
MONTANA	F-155(9)	16

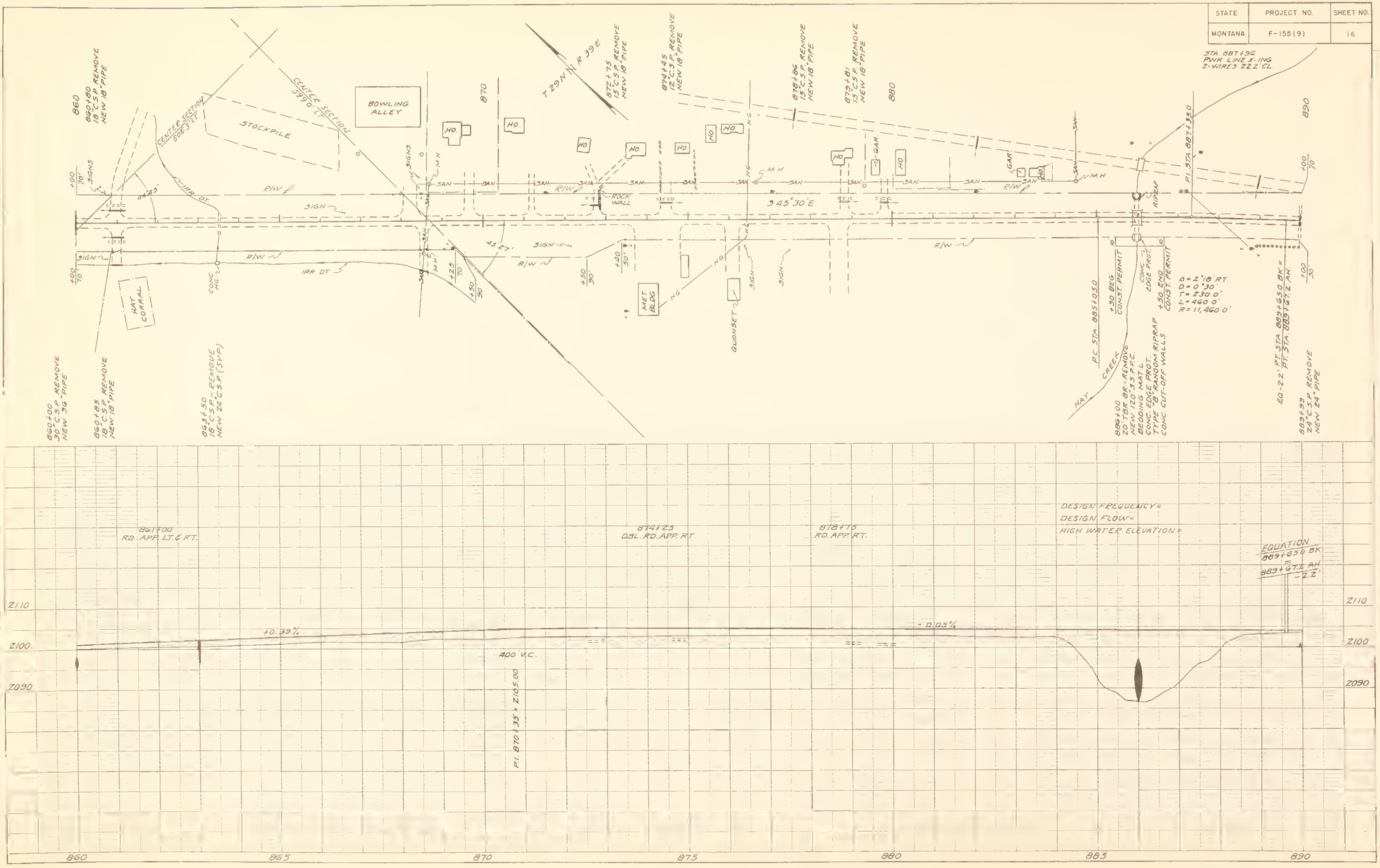

STA. 887+96
PWR. LINE X-ING
2-WIRES 22.2' CL.
860
860+80 18" C.S.P. REMOVE NEW 18" PIPE
870
T 29 N R 39 E
872+75 15" C.S.P. REMOVE NEW 18" PIPE
874+45 12" C.S.P. REMOVE NEW 18" PIPE
878+86 15" C.S.P. REMOVE NEW 18" PIPE
879+81 15" C.S.P. REMOVE NEW 18" PIPE
880
890
BOWLING ALLEY
CENTER SECTION 599.0' LT.
CENTER SECTION 606.3' LT.
STOCKPILE
HO.
GAR
ROCK WALL
S 45°30' E.
P.I. STA. 887+35.0
RIPRAP
SIGNS
SIGN
R/W
IRR. DT.
SAN
M.H.
NG
45°27'
HAY CORRAL
CONC. HG
MET. BLDG.
QUONSET
P.C. STA. 885+05.0
+50 BEG. CONST. PERMIT
CONC. EDGE PROT.
+50 END CONST. PERMIT
Δ = 2°18' RT.
D = 0°30'
T = 230.0'
L = 460.0'
R = 11,460.0'
EQ. -2.2' P.T. STA. 889+65.0 BK. = P.T. STA. 889+67.2 AH.
HAY CREEK
860+00 30" C.S.P. REMOVE NEW 36" PIPE
860+85 18" C.S.P. REMOVE NEW 18" PIPE
863+50 18" C.S.P. REMOVE NEW 24" C.S.P. (SYP.)
886+00 20' TBR. BR. REMOVE NEW 120" S.S.P.P.C. BEDDING MAT'L. CONC. EDGE PROT. TYPE "B" RANDOM RIPRAP CONC. CUT-OFF WALLS
889+99 24" C.S.P. REMOVE NEW 24" PIPE
861+00 RD. APP. LT. & RT.
874+25 DBL. RD. APP. RT.
878+75 RD. APP. RT.
DESIGN FREQUENCY =
DESIGN FLOW =
HIGH WATER ELEVATION =
EQUATION 889+65.0 BK. = 889+67.2 AH. -2.2'
+0.39%
-0.05%
400' V.C.
P.I. 870+35 = 2105.00
2110
2100
2090
860
865
870
875
880
885
890

PLATE 1 - PLAN-PROFILE

Use of Notes

Notes on plan sheets should be brief, clear and consistent. Installations and removals will be noted by station and brief description. Detailed descriptions are included in summary sheets, but should not be included on plan and profile sheets.

Typical notes for some common items are presented below:

Item	Typical Note
Existing sign	SIGN
New Culvert	865 + 00 NEW 24" PIPE
Existing culvert to be removed	870 + 30 24" C.M.P. REMOV
New road approach	875 + 20 RD. APP. RT.
New metal guard rail	882 + 00 to 887 + 30 NEW METAL G.R. RT.
New riprap	892 + 35 RIPRAP RT.

North Arrows

North arrows will be shown on plan views and will be uniform within each set of plans.

Mainline Plan and Profile Sheets

Specific guidelines for the preparation of mainline plan and profile sheets are presented below. The guidelines are supplemented by two model sheets.

Topography

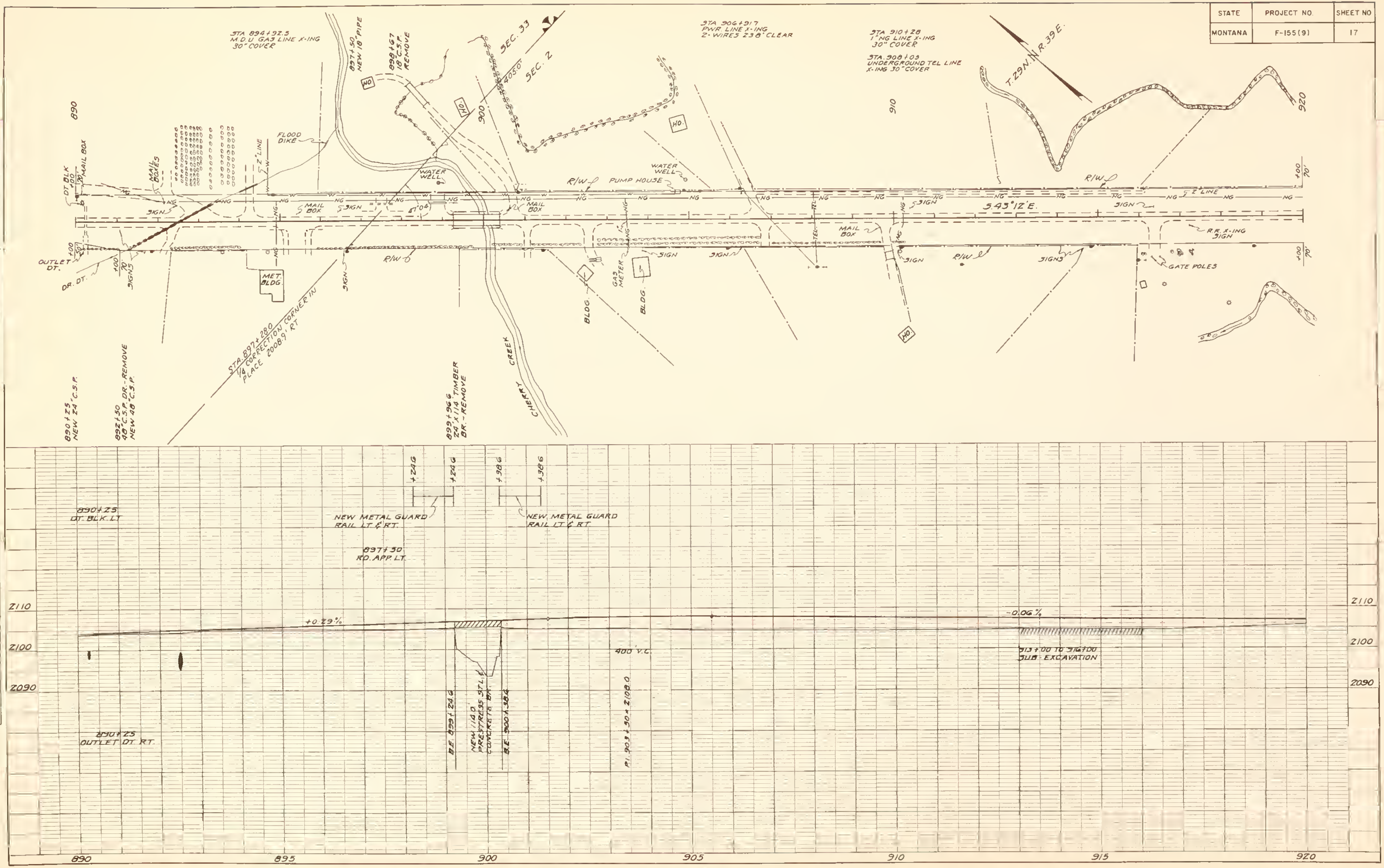
Topography to be shown includes utilities, irrigation and drainage facilities, buildings and other items pertinent to construction operations.

Where overhead utilities cross the centerline, notes will indicate the centerline stations, the types of utilities, the numbers of wires and the clearances above the present ground. Where underground utilities cross the centerline, notes will indicate the centerline stations, the types of utilities and the sizes and depths of pipes.

Township, Range and Section Lines

Township lines, range lines and section lines will be shown on plan views with ties to the highway centerline.

STATE	PROJECT NO.	SHEET NO.
MONTANA	F-155(9)	17



Roadway Alignment Data

Horizontal alignment data should be provided as follows:

- Staked and projected alignments will be represented, showing equations. The staked centerline within projections will be dashed. Nonparallel projections should show ties between staked and projected lines.
- Bearings will be written near the lines to which they apply.
- Curve points will be identified by station.
- Lists of curve data, including full superelevation, will be placed inside the curves to which they apply.

Vertical alignment data should be provided as follows:

- Profile grade lines will be shown in relation to original ground lines. Ground lines should be free-hand drawn where it will help in interpretation of the plans.
- P.C.'s and P.T.'s will be depicted with small circles on the grade line, but they will not be identified.
- P.I.'s will be described by notes indicating their full stations and elevations. P.I. notes will be placed above the profile for crest curves. Neither tangent lines nor P.I.'s will be depicted for vertical curves.
- Lengths of vertical curves will be written above the profile for sag curves and below the profile for crest curves.
- Tangent gradients will be shown.

Right-of-Way, Easements and Control of Access

Right-of-way limits will be shown. Breaks in right-of-way alignments will be described by centerline stations and offsets. Stations will be written as plus stations and offsets will be expressed in feet.

Easement areas and control of access limits, as applicable, will be clearly defined. Where control of access limits do not coincide with right-of-way limits, each should be clearly labeled.

Items to be Installed or Constructed

Items to be installed or constructed will be shown with standard symbols wherever standard symbols are applicable. The symbols will be supplemented by notes indicating station locations and brief descriptions of the items. Refer to the section on "Use of Notes."

Items to be Removed

Items within the right-of-way limits to be removed will be shown. Those items to be removed by non-contractor personnel will be clearly noted.

Hydraulic Data

When the design flow exceeds 500 C.F.S, the following hydraulic data must be shown on the profile view of the plan and profile sheets:

- Design frequency
- Design flow
- High water elevation

Drafting

Mainline plan and profile sheets should be handlettered as follows:

Plan view

Centerline, station marks	No. 3 pen
Ten stationing	No. 3 pen, about 0.2" high
Other information	No. 1 pen

Profile view

Grade line	No. 3 pen
Other information	No. 1 pen

Plan Views of Geometric Layouts

Plan views of geometric layouts are used where mainline plan and profile sheets cannot adequately show horizontal alignment details of large or complex facilities such as interchanges and major intersections.

The model sheet on the next page shows a typical geometric layout for an interchange.

Contents

The contents of geometric layouts generally will be the same as the contents of plan views on mainline plan and profile sheets, with these exceptions:

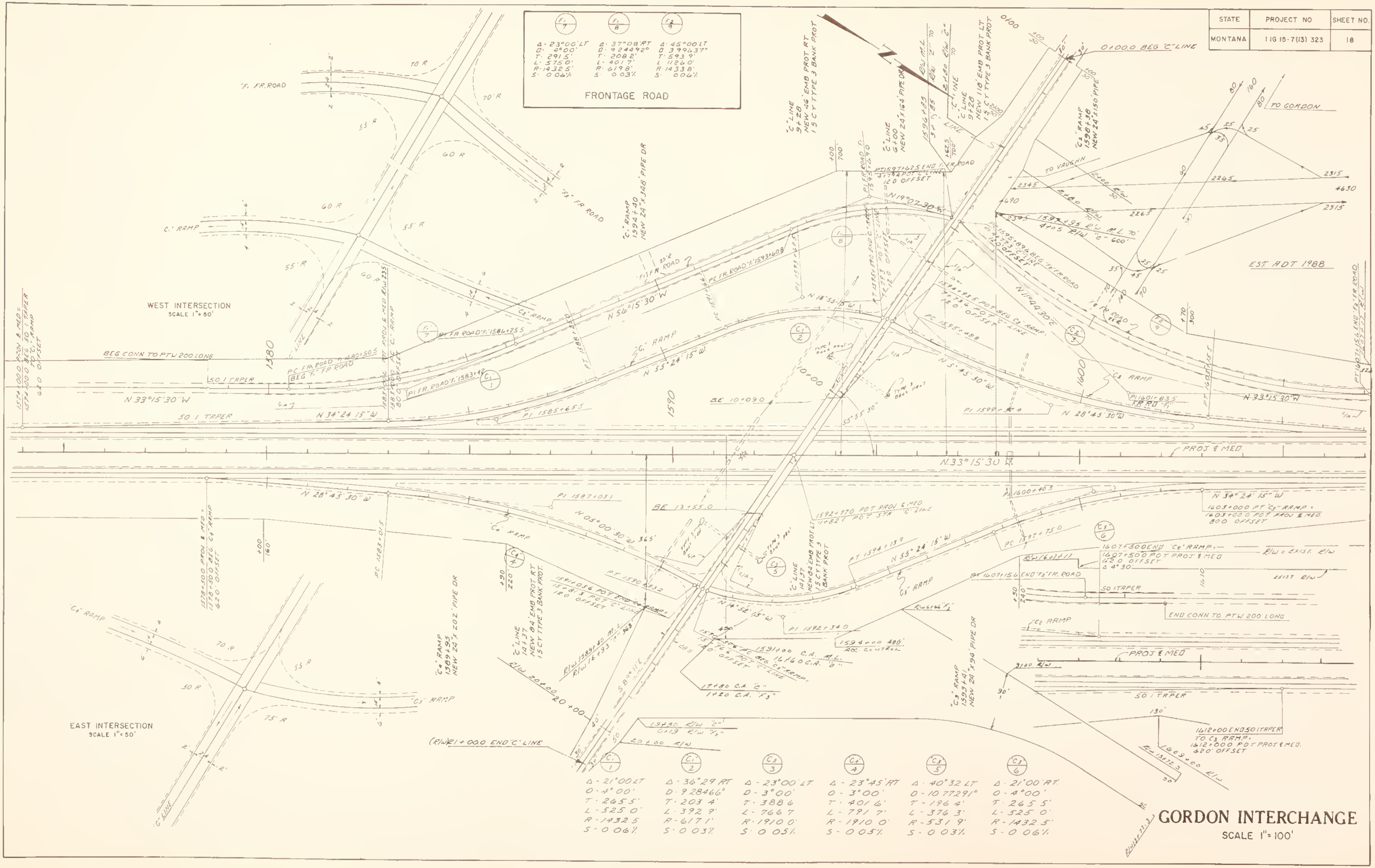
- Topography will not be shown.
- The names of the features will be clearly shown on the right sides of the sheets.

Drafting

Geometric layouts should be drafted as follows:

Leroy:	Feature names	290 template
Handletter:	Centerlines, station marks	No. 3 pen
	Ten stationing	No. 3 pen, about 0.2" high
	Other information	No. 1 pen

STATE	PROJECT NO	SHEET NO.
MONTANA	I IG 15-7(13) 323	18



GORDON INTERCHANGE

SCALE 1"= 100'

Supplemental Profiles

Supplemental profiles are used to show vertical alignments of improvements other than mainline roadways, such as frontage roads and ramps.

Supplemental profiles should be drawn on cross-section paper as used for the model sheet on the next page.

Contents

Supplemental profiles will contain the same types of information as shown on profile views of mainline plan and profile sheets. In addition, the names of the supplemental profiles will be shown on the right sides of the sheets.

Drafting

Supplemental profiles should be drafted as follows:

Leroy:	Feature names	290 template
Handletter:	Grade line	No.3 pen
	Other information	No.1 pen

Contour Grading Plans

Contour grading plans should be prepared for all interchanges. Model contour grading plans are shown on the two sheets following the supplemental profiles.

Contents

Contour grading plans should show the following items:

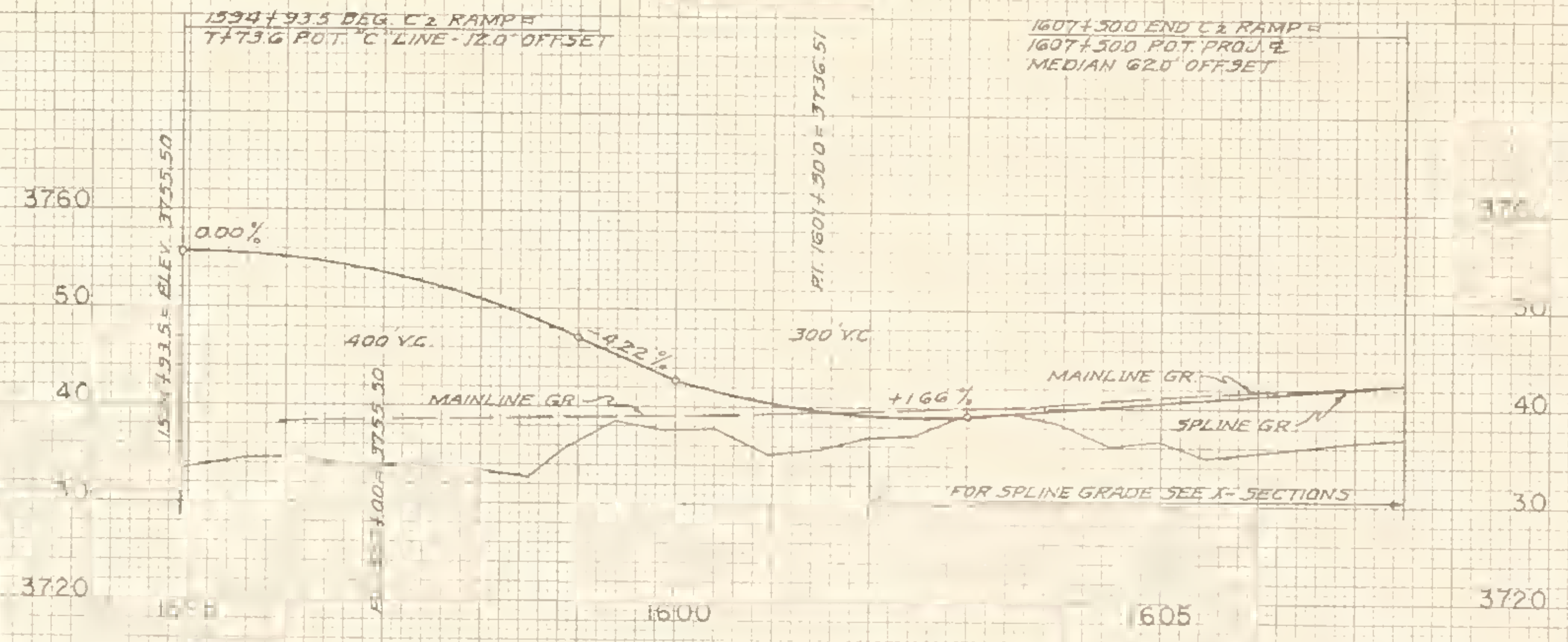
- Centerlines and station marks for mainlines, crossroads and frontage roads
- Base lines and station marks for ramps
- Object lines showing traffic lanes, shoulders and drainage structures
- Arrows showing the direction of flow through drainage structures
- Names or other identification for crossroads, ramps and frontage roads
- Elevation lines at 2-foot intervals with elevations noted at 10-foot intervals
- Names and scales of interchanges on the right sides of the sheets

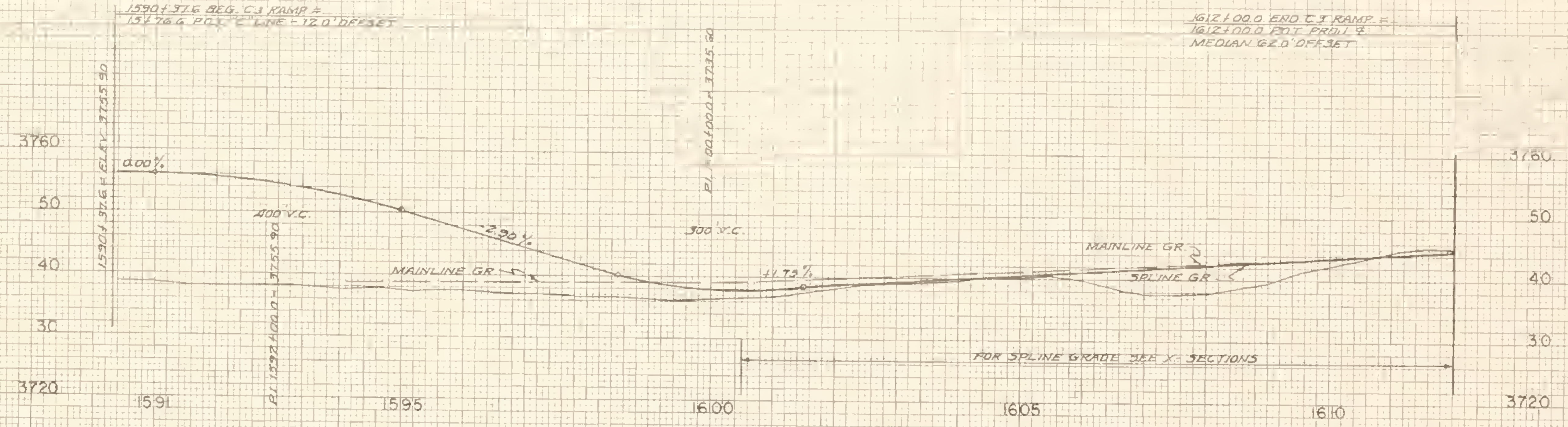
Drafting

Contour grading plans should be drafted as follows:

Leroy:	Names and scales of interchanges	290 template
Handletter:	Centerlines, base lines, station marks, notes and elevations	No. 3 pen
	Elevation lines at 10-foot intervals	No. 2 pen
	Other lines	No. 1 pen

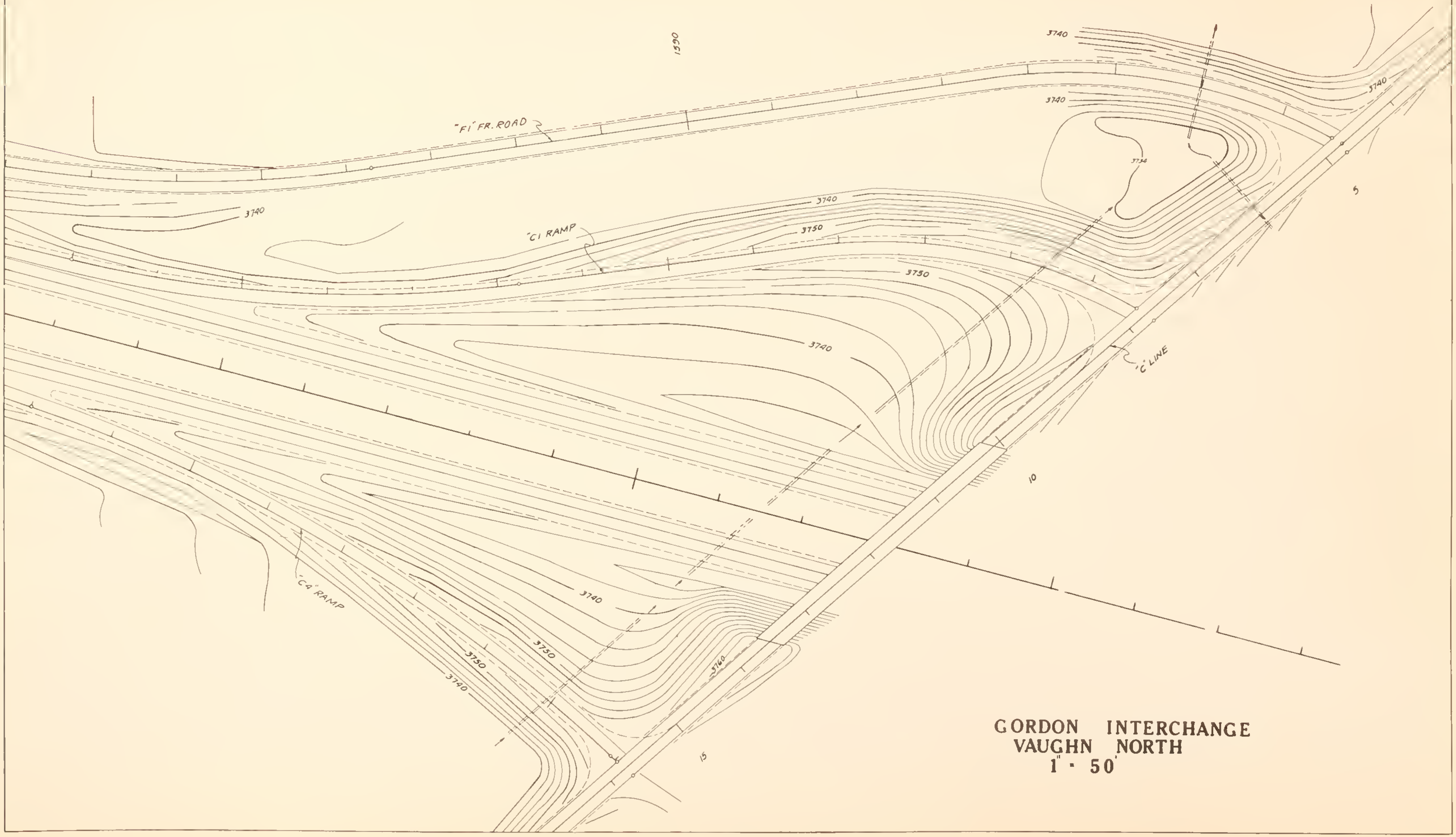
STATE	PROJECT NO	SHEET NO
MONTANA	I IG 15-7(13) 323	19





"C 2" & "C 3" RAMP PROFILES
GORDON INTERCHANGE

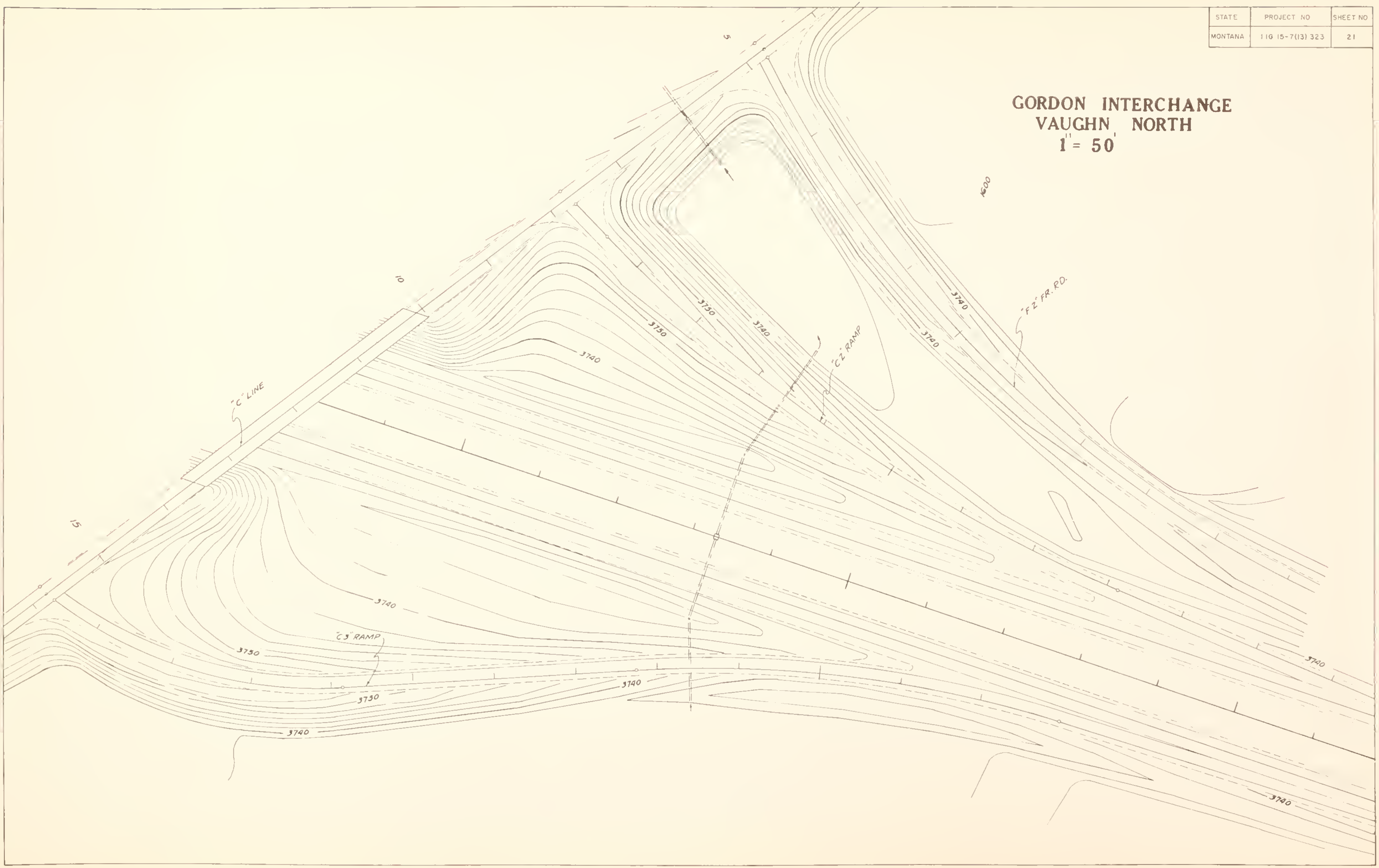
STATE	PROJECT NO.	SHEET NO.
MONTANA	I IG 15-7(13) 323	20



GORDON INTERCHANGE
VAUGHN NORTH
1" = 50'

STATE	PROJECT NO	SHEET NO
MONTANA	I IG 15-7(13) 323	21

GORDON INTERCHANGE
VAUGHN NORTH
1" = 50'

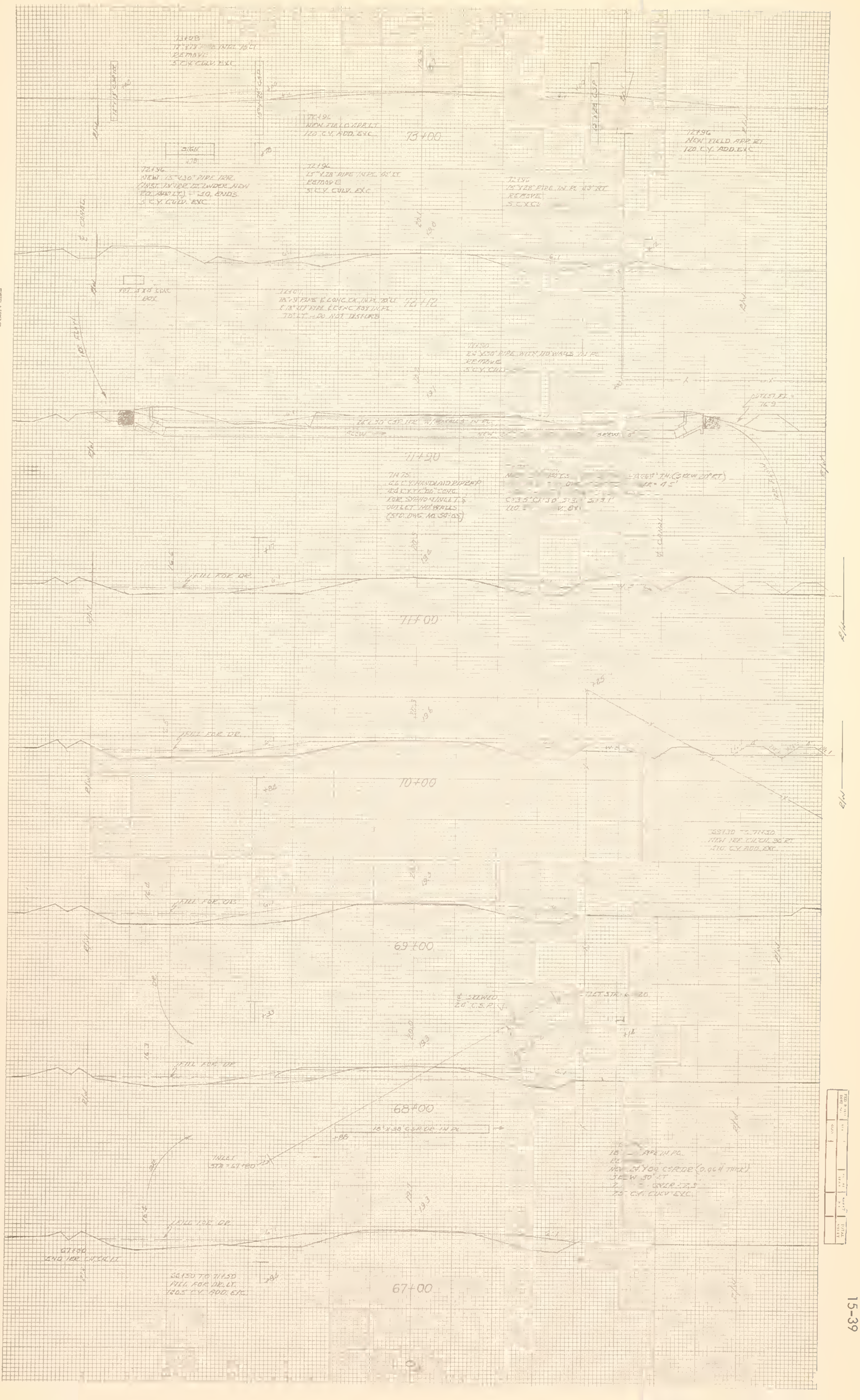


CROSS-SECTION SHEETS

Cross-section sheets should provide graphical pictures of the relationships between the proposed roadway and the existing ground surface. Model cross-section sheets are shown on the next two pages.

Areas and volumes need not be shown on the cross-section sheets if computer earthwork runs are available.

Guidelines for preparing cross sections are presented in Chapter Five.



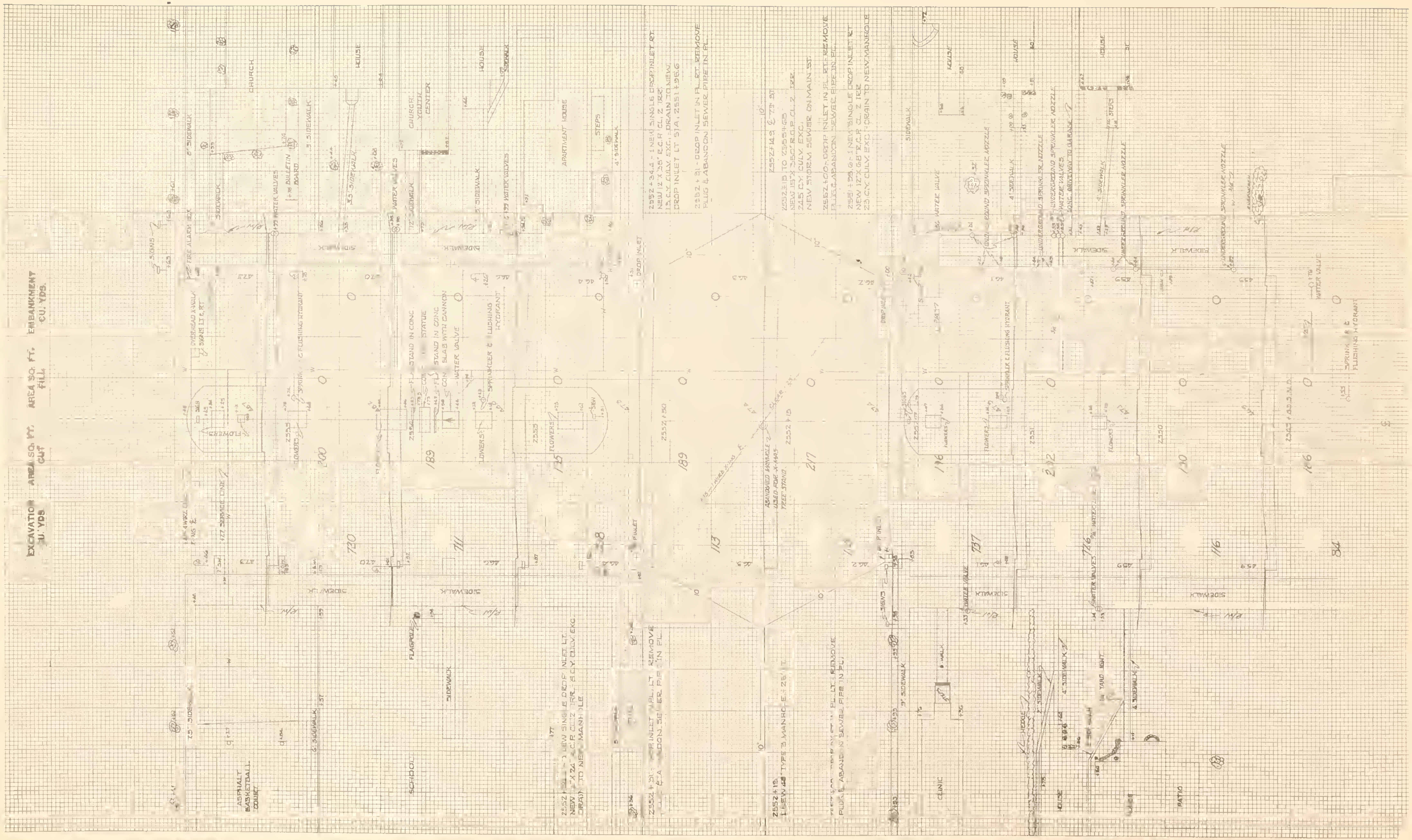
KEUFFEL & ESSER CO.
MADE IN U.S.A.

K+E STANDARD CROSS SECTION

KEUFFEL & ESSER CO.
MADE IN U.S.A.

PLOTTED ___ F.A ___
CHECKED ___
INKED ___ SHEET NO ___

FED. ROAD DEPT. NO.	STATE		FISCAL YEAR	SHEET NO.	TOTAL SHEETS
	40NJ				



EXCAVATION CU. YDS.
AREA SQ. FT. CUT
AREA SQ. FT. FILL
EMBANKMENT CU. YDS.
CHURCH
HOUSE
CHURCH YOUTH CENTER
APARTMENT HOUSE
STEPS
SIDEWALK
WATER VALVES
FIRE ALARM BOX
SIGNS
BULLETIN BOARD
DROP INLET
FLOWERS
STAND IN CONC.
STATUE
SLAB WITH CANNON
WATER VALVE
SPRINKLER & FLUSHING HYDRANT
UNDERGROUND SPRINKLER NOZZLE
CONC. DRIVEWAY TO GARAGE
2552+50
2552+15
2551
2550
2549+42.5 IN. D.
200
189
175
189
217
196
202
130
116
730
711
113
737
776
116
84
ASPHALT BASKETBALL COURT
SCHOOL
FLAGPOLE
CLINIC
HOUSE
PATIO
HEDGE
YARD LIGHT
2552+34.4 - 1 NEW SINGLE DROP INLET RT. NEW 12"X 38' R.C.P. CL. 2 IRR. 15 C.Y. CULV. EXC. - DRAIN TO NEW DROP INLET LT. STA. 2551+96.6
2552+21 - DROP INLET IN PL. RT. REMOVE PLUG & ABANDON SEWER PIPE IN PL.
2552+15 TO 2555+65 NEW 15"X 350' R.C.P. CL. 2 IRR. 245 C.Y. CULV. EXC. NEW STORM SEWER ON MAIN ST.
2552+10 - DROP INLET IN PL. RT. REMOVE PLUG & ABANDON SEWER PIPE IN PL.
2551+98.6 - 1 NEW SINGLE DROP INLET RT. NEW 12"X 68' R.C.P. CL. 2 IRR. 23 C.Y. CULV. EXC. - DRAIN TO NEW MANHOLE
2552+15 1 NEW TYPE 3 MANHOLE 25' LT.
ABANDONED MANHOLE USED FOR X-MAS TREE STAND

TEMP ____ PLOTTED ____ F.A. ____
AREAS ____ CHECKED ____
CHECKED ____ INKED ____ SHEET NO ____

DESIGN STANDARDS

Chapter One

DESIGN STANDARDS

PURPOSE

Standards have been developed to guide the design of highways and to ensure that motorist convenience, environmental, safety and esthetic considerations are implemented in the most economical manner consistent with the highway service considerations.

SOURCE OF STANDARDS

The basic design criteria in this section are taken from the AASHO Manual entitled "A Policy on Geometric Design of Rural Highways, 1965." Reference should be made to the AASHO Manual for design criteria not covered in this section, and for more comprehensive background information regarding the development of criteria.

DEPARTURE FROM STANDARDS

Design policies and standards generally represent minimum values. Higher standards should be used within reasonable economic limits. To insure uniform practice on a statewide basis, lower design standards may not be used without approval from the Administrator, Preconstruction Division.

DESIGN CONTROLS

Three basic factors control the selection of design standards:

1. The anticipated TRAFFIC VOLUME
2. The TERRAIN
3. An appropriate DESIGN SPEED.

These design controls will be established during the project planning phase and documented in the Planning Report.

The various geometric design standards are selected on the basis of one or more of the design controls. These relationships are presented below for each type of highway

GEOMETRIC DESIGN STANDARDS

Geometric design standards for interstate, primary and secondary highways are summarized on Standard Sheet No. 101. Where there are desirable minimum standards and absolute minimum standards, only the desirable minimum standards are shown in the table. Absolute minimum standards are contained in the notes. (Nomenclature for cross-section elements is illustrated on page 1 - 3.) The geometric design standards are identified by the elements of design control. Their relationships are defined below.

Degree of Curvature

The combination of design speed and maximum superelevation controls the maximum degree of curvature. The table shows absolute maximum degrees of curvature. Flatter curves must be provided where possible. Guidelines for desirable horizontal alignment are presented in Chapter Three.

In rural areas, all curves 1° 30' or sharper will have spiral transitions as provided on Standard Sheet No. 301. Spiral transititions are discussed in Chapter Three.

Superelevation

The maximum superelevation rate has been established at 0.08 ft. of vertical rise per 1.0 ft. of horizontal distance. Guidelines for the application of superelevation are presented in Chapter Three.

Stopping Sight Distance

Minimum stopping sight distance is controlled by design speed. All highway design will provide minimum stopping sight distance. Where practicable, the design should provide desirable stopping sight distance. Minimum stopping sight distances are permitted only under extreme conditions.

Stopping sight distance is most important when designing vertical alignment. Guidelines for ensuring adequate stopping sight distance are presented in Chapter Four.

Gradients

The table shows maximum gradients for each design speed and type of terrain.

Where economically feasible, grades should be less than the maximum. Under certain conditions steeper grades are permitted. Minimum grades sometimes are stipulated to provide adequate longitudinal drainage.

Guidelines for the design of vertical alignment are presented in Chapter Four.

Passing Sight Distance

On 2-lane highways, consideration should always be given to providing passing sight distance. Guidelines on providing passing sight distance are presented in Chapter Four.

Typical Sections

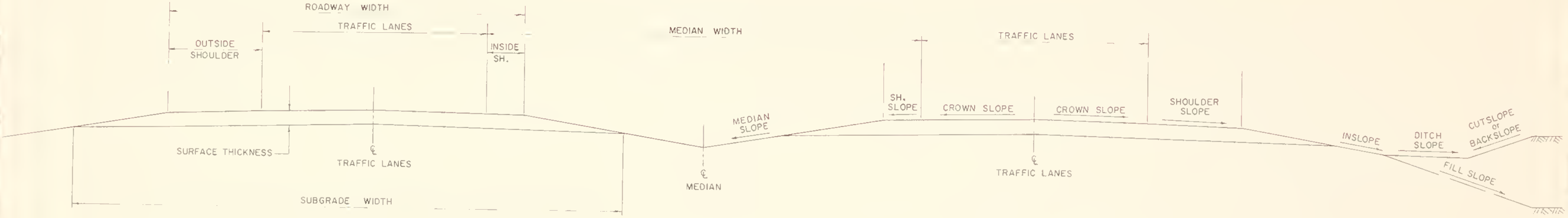
The tables of typical sections on Standard Sheet No. 101 identify the typical sections to be used. Interstate typical sections are identified by median width. Primary and secondary typical sections are identified by roadway width.

Typical sections to be used for frontage roads are presented on Standard Sheet No. 109.

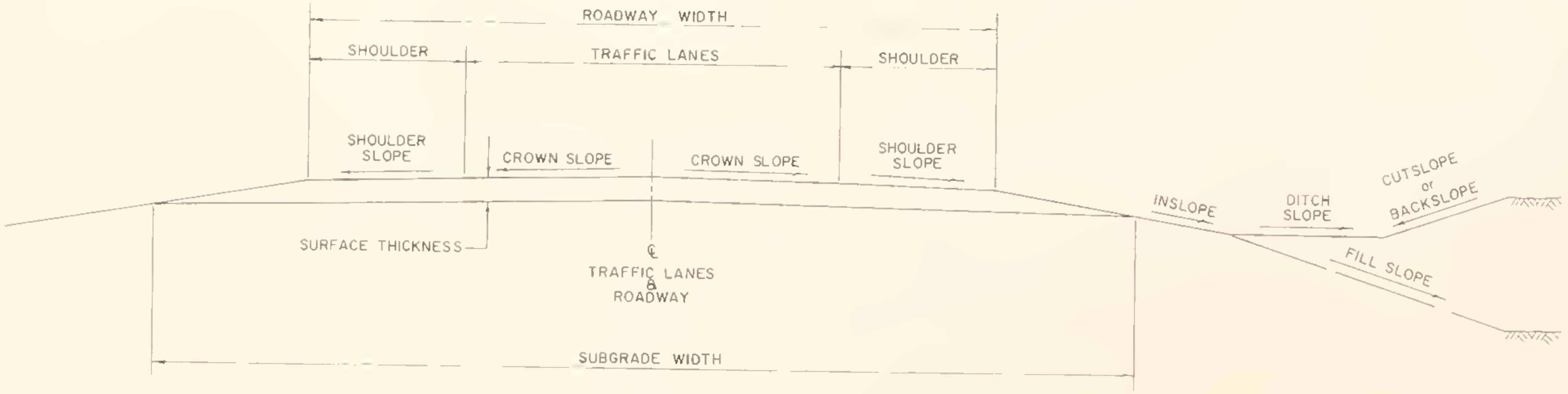
MISCELLANEOUS POLICIES AND CRITERIA

There are numerous design policies and criteria that cannot be described or illustrated adequately in the tables of Geometric Design Standards. Subsequent sections of this manual present current policies and procedures to be followed by highway designers.

INTERSTATE NOMENCLATURE



PRIMARY AND SECONDARY NOMENCLATURE



INTERSTATE

		Terrain or Area [9]			
		Flat	Rolling	Mountainous	Urban
Min. Design Speed, MPH		70	60	50	50
Max. Degree of Curvature [1]		3° 30'	5° 00'	7° 30'	7° 30'
Desirable Min. Stopping Sight Distance, Ft. [2]		850	650	450	450
Max. Gradient, %		3	4	5[3]	5
Min. Widths, Ft.	Traffic Lanes	4 @ 12'	4 @ 12'	4 @ 12'	4 @ 12'
	Inside Shoulders [4]	4	4	4	4
	Outside Shoulders	10	10	10[5]	10
	Median	36	36	16[6]	16[6]
Cut Slopes, Cut Depths at Slope Stake [7]	0' - 5'	5:1	5:1	5:1	-
	5' - 10'	4:1	4:1	3:1	-
	10' - 15'	3:1	3:1	2:1	-
	Over 15'	2:1	2:1	1½:1	-
Desirable Fill Slopes, Fill Depths at Slope Stake [8]	0' - 10'	6:1			
	10' - 20'	4:1			
	Over 20'	2:1			
Surface Slopes, Ft./Ft.	Crown	0.02			
	Inside Shoulder	0.02			
	Outside Shoulder	0.0375			

Median Width	Typical Section No.
36' to 44'	1
44' to 76'	2
76' and over	3
10'	4
12' to 20'	5

NOTES

[1] Based on the maximum superelevation rate of 0.08 ft./ft.

[2] The absolute minimum stopping sight distances are 600 ft., 475 ft., 350 ft. and 350 ft., respectively.

[3] Gradients up to 7% may be provided in rugged terrain, subject to prior approval.

[4] Inside shoulders will be 4' wide except where continuous barrier curbs are used on narrow medians. Curbs will be offset at least 1 ft., preferable 1.5 ft., from the edge of the traffic lane. Where vertical elements more than 12 in. high, other than abutments, piers or walls, are located in the median, the face of such element shall be offset at least 3.5 ft. from the edge of of the traffic lane.

[5] Outside shoulders may be reduced to a minimum of 6 ft. in mountainous terrain involving high cost of additional width.

[6] Medians may be reduced to a minimum of 10 ft. in urban areas of high right-of-way cost, in rugged mountainous terrain and on long and costly bridges.

[7] For cut slopes in rock, use Standard Sheet No. 110.

[8] In rock fills over 10 ft. high, the standard fill slope is 1½:1. Except in rock fills, the absolute minimum fill slopes are 6 : 1 for 0' - 5', 4 : 1 for 5' - 10', 3:1 for 10' - 15', 2 : 1 for 15' - 20' and 1½ : 1 for over 20'. The use of 1½ : 1 slopes requires prior analysis of slope stability.

[9] Combinations of maximum design standards will require prior approval of the Administrator, Preconstruction Division.

PRIMARY AND SECONDARY

		Terrain [8]			
		Flat	Rolling	Mountainous	Special[7]
Min. Design Speed, MPH		70	60	50	40
Max. Degree of Curvature [1]		3° 30'	5° 00'	7° 30'	12° 30'
Desirable Min. Stopping Sight Distance, Ft. [2]		850	650	450	300
Min. Passing Sight Distance, Ft.		2500	2100	1800	1500
Max. Gradient, %		3	5	6	7
Roadway Widths, Ft., For Future ADT (20 years) [3]	0 - 100	26	26	26	26
	100 - 450	28	28	28	28
	450 - 700	30	30	28	28
	700 - 1400	36	34	34	34
	1400 - 2800	40	40	40	40
	Over 2800	44	44	44	44
Cut Slopes, Cut Depths at Slope Stake [4]	0' - 5'	5:1	5:1	5:1	5:1
	5' - 10'	4:1	4:1	3:1	3:1
	10' - 15'	3:1	3:1	2:1	2:1
	15' - 20'	2:1	2:1	1½:1	1½:1
	Over 20'	1½:1	1½:1	1½:1	1½:1
Fill Slopes, Fill Depths at Slope Stake [5]	0' - 10'	6:1			
	10' - 20'	4:1			
	Over 20'	2:1			
Surface Slopes, Ft./Ft.	Crown	0.02			
	Shoulder	[6]			

Roadway Width	Typical Section No.
28' to 44'	6
26'	7

NOTES

[1] Based on the maximum superelevation rate of 0.08 ft./ft.

[2] The absolute minimum stopping sight distances are 600 ft., 475 ft., 350 ft. and 350 ft., respectively.

[3] Each roadway width comprised of two 12 ft. traffic lanes plus shoulders.

[4] For cut slopes in rock, use Std. Sht. No. 110.

[5] In rock fills over 10 ft. high, the standard fill slope is 1½ : 1. Except in rock fills, the absolute minimum fill slopes are 6:1 for 0' - 5', 4:1 for 5' - 10', 3:1 for 10' - 15', 2:1 for 15' - 20' and 1½:1 for over 20'. The use of 1½:1 slopes requires prior analysis of slope stability.

[6] Shoulder slope same as crown slope except as shown on typical sections.

[7] This column will be used only with the prior approval of the Preconstruction Engineer.

[8] Combinations of maximum design standards will require prior approval of the Administrator Preconstruction Division.

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

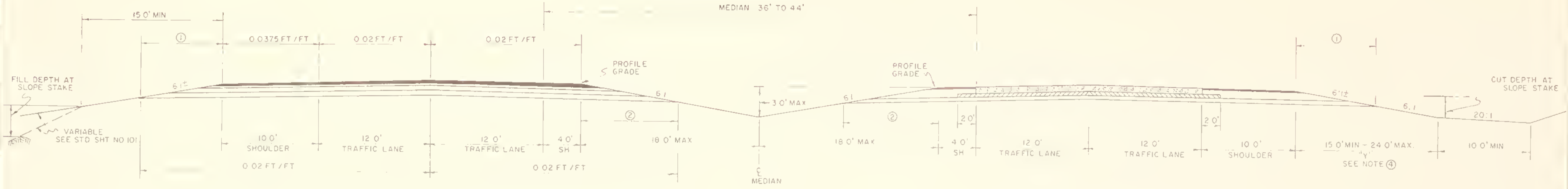
GEOMETRIC DESIGN STANDARDS

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 101

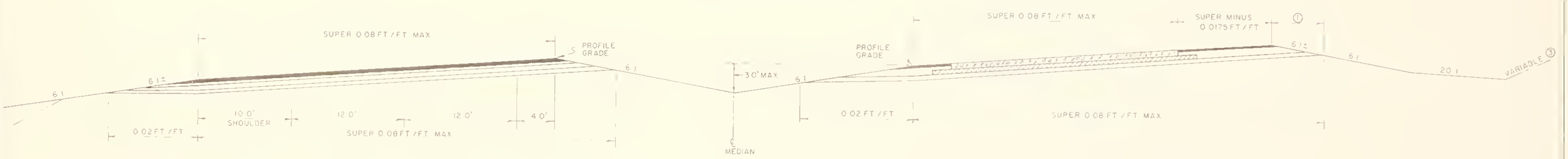
TANGENT SECTION



TYPICAL BITUMINOUS SECTION

TYPICAL CONCRETE SECTION

CURVE SECTION ⑤



TYPICAL BITUMINOUS SECTION

TYPICAL CONCRETE SECTION

NOTES

① COMPUTE DISTANCE TO NEAREST FOOT COMPUTE INTERMEDIATE SURFACING WIDTHS TO NEAREST TENTH OF FOOT

② COMPUTE DISTANCE TO NEAREST TENTH OF A FOOT BASED ON A TRUE 6 1 SLOPE

③ IN NORMAL CUT SECTIONS, SEE STANDARD SHEET NUMBER 101 FOR BACKSLOPE IN ROCK CUT SECTIONS, SEE STANDARD SHEET NUMBER 110 FOR DITCH WIDTH AND BACKSLOPE

④

SURFACE THICKNESS AT FINISHED SHOULDER	"Y" IN FEET
0 - 1 35	15
1 40 - 1 50'	16
1 55 - 1 65	17
1 70 - 1 80	18
1 85 - 1 95	19
2 00 - 2 10'	20
2 15 - 2 25	21
2 30 - 2 40'	22
2 45 - 2 55	23
2 60 - 2 70'	24
2 75 & OVER	*

* SPECIAL DESIGN SUBJECT TO HEADQUARTERS APPROVAL

⑤ SEE STANDARD SHEET NUMBER 301 FOR SUPERELEVATION

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

TYPICAL SECTION NO 1

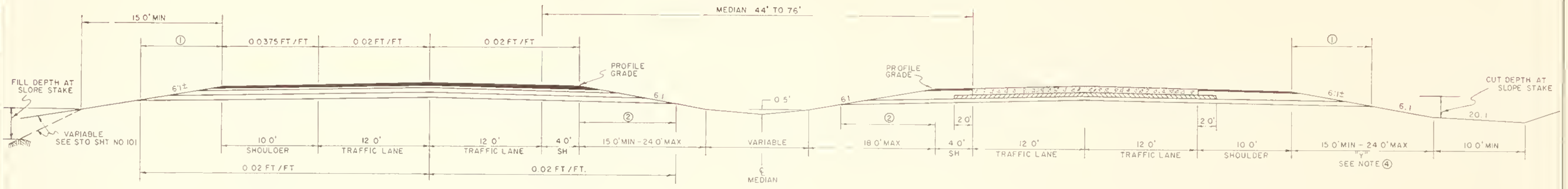
FOR MEDIANS OF 36' TO 44'

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO 102

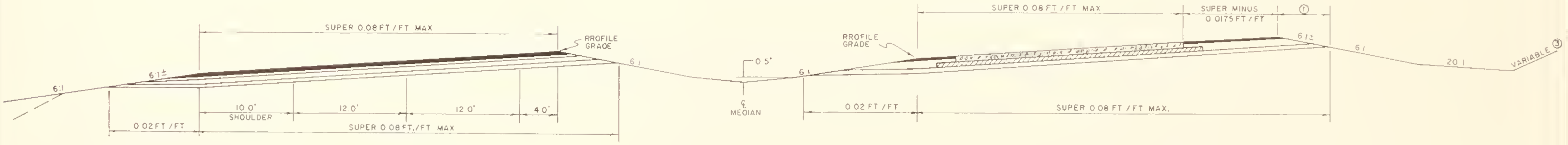
TANGENT SECTION



TYPICAL BITUMINOUS SECTION

TYPICAL CONCRETE SECTION

CURVE SECTION ⑤



TYPICAL BITUMINOUS SECTION

TYPICAL CONCRETE SECTION

NOTES

① COMPUTE DISTANCE TO NEAREST FOOT. COMPUTE INTERMEDIATE SURFACING WIDTHS TO NEAREST TENTH OF FOOT.

② COMPUTE DISTANCE TO NEAREST TENTH OF A FOOT BASED ON A TRUE 6:1 SLOPE

③ IN NORMAL CUT SECTIONS, SEE STANDARD SHEET NUMBER 101 FOR BACKSLOPE. IN ROCK CUT SECTIONS, SEE STANDARD SHEET NUMBER 110 FOR DITCH WIDTH AND BACKSLOPE.

④

SURFACE THICKNESS AT FINISHED SHOULDER	"Y" IN FEET
0 - 1.35'	15
1.40 - 1.50'	16
1.55 - 1.65'	17
1.70 - 1.80'	18
1.85 - 1.95'	19
2.00 - 2.10'	20
2.15 - 2.25'	21
2.30 - 2.40'	22
2.45 - 2.55'	23
2.60 - 2.70'	24
2.75 & OVER	*

* SPECIAL DESIGN SUBJECT TO HEADQUARTERS APPROVAL

⑤ SEE STANDARD SHEET NUMBER 301 FOR SUPERELEVATION.

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

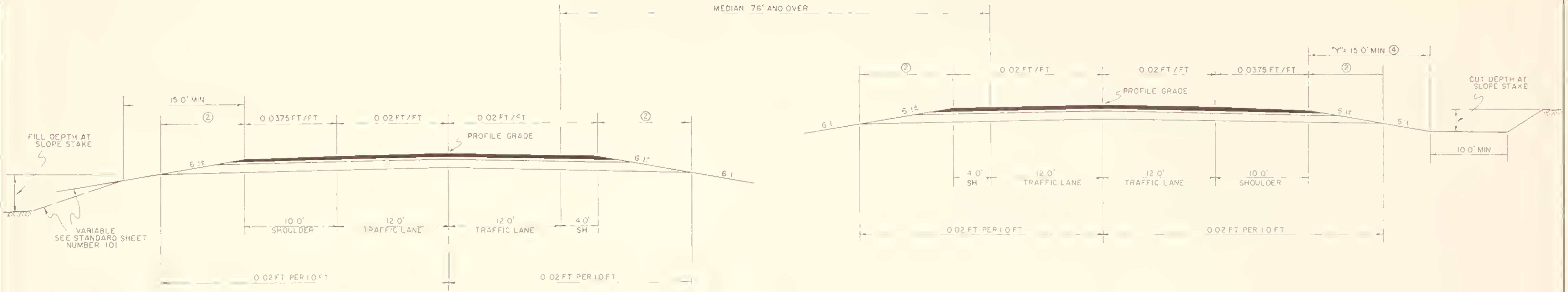
TYPICAL SECTION NO. 2
FOR MEDIANS OF 44' TO 76'

APPROVED

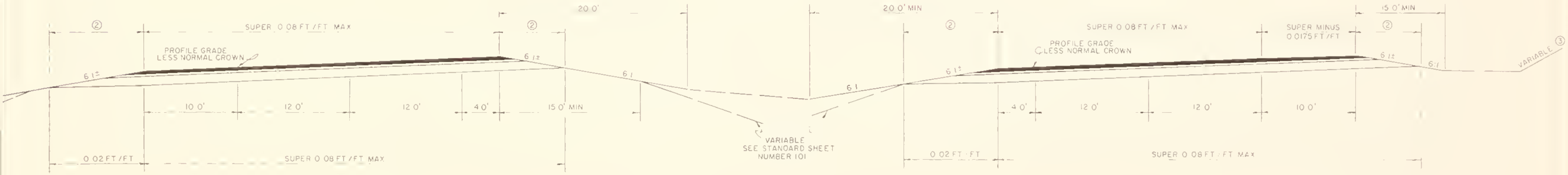
STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 103

TANGENT SECTION



CURVE SECTION ⑤



NOTES

① GENERALLY, THIS TYPICAL SECTION WILL BE USED ONLY WHERE TERRAIN WARRANTS THE USE OF INDEPENDENT GRADE LINES MEDIAN SLOPE INTERSECTIONS WILL BE DETERMINED BY THE DESIGNER TO MEET INDIVIDUAL CONDITIONS IN CASES WHERE MEDIAN WIDTHS VARY (FROM 36' TO 76' AND OVER) WITHIN A GIVEN PROJECT, THE PROFILE GRADE SHALL BE CARRIED ON THE FINISHED MEDIAN SHOULDER

WHERE POSSIBLE, NATURAL GROWTH IN PLACE BETWEEN ROADWAYS SHALL BE PRESERVED

② COMPUTE DISTANCE TO NEAREST FOOT

③ IN NORMAL CUT SECTIONS, SEE STANDARD SHEET NUMBER 101 FOR BACKSLOPE IN ROCK CUT SECTIONS, SEE STANDARD SHEET NUMBER 110 FOR DITCH WIDTH AND BACKSLOPE

④

SURFACE THICKNESS AT FINISHED SHOULDER	"Y" IN FEET
0 - 1 35	15
1 40 - 1 50'	16
1 55 - 1 65'	17
1 70 - 1 80'	18
1 85 - 1 95'	19
2 00 - 2 10'	20
2 15 - 2 25'	21
2 30 - 2 40'	22
2 45 - 2 55'	23
2 60 - 2 70'	24
2 75 & OVER	*

* SPECIAL DESIGN SUBJECT TO HEADQUARTERS APPROVAL

⑤ SEE STANDARD SHEET NUMBER 301 FOR SUPERELEVATION

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

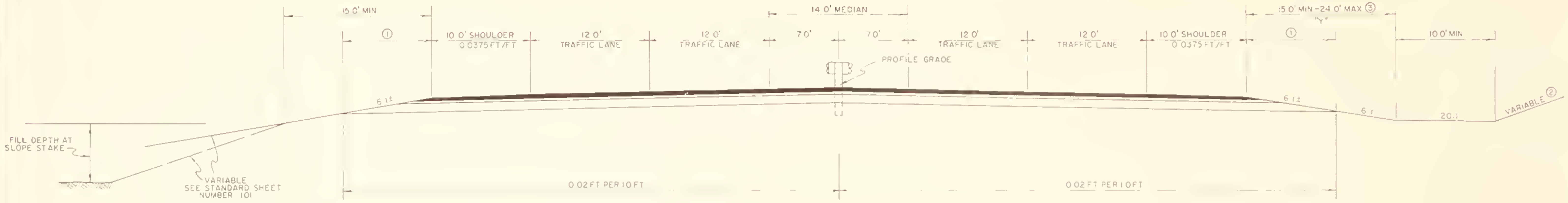
TYPICAL SECTION NO 3
FOR MEDIANS OF 76' AND OVER
SEE NOTE ①

APPROVED

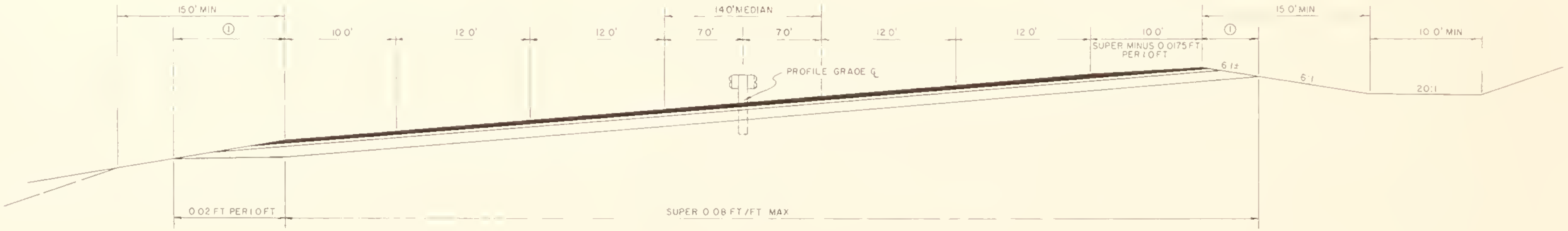
STATE HIGHWAY ENGINEER

STANDARD SHEET NO 104

TANGENT SECTION



CURVE SECTION ④



NOTES

① COMPUTE DISTANCE TO NEAREST FOOT

② IN NORMAL CUT SECTION, SEE STANDARD SHEET NUMBER 101 FOR BACKSLOPE. IN ROCK CUT SECTIONS, SEE STANDARD SHEET NUMBER 110 FOR DITCH WIDTH AND BACKSLOPE

③

SURFACE THICKNESS AT FINISHED SHOULDER	"Y" IN FEET
0-1.35'	15
1.40-1.50'	16
1.55-1.65'	17
1.70-1.80'	18
1.85-1.95'	19
2.00-2.10'	20
2.15-2.25'	21
2.30-2.40'	22
2.45-2.55'	23
2.60-2.70'	24
2.75 & OVER	*

* SPECIAL DESIGN SUBJECT TO HEADQUARTERS APPROVAL

④ SEE STANDARD SHEET NUMBER 301 FOR SUPERELEVATION

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

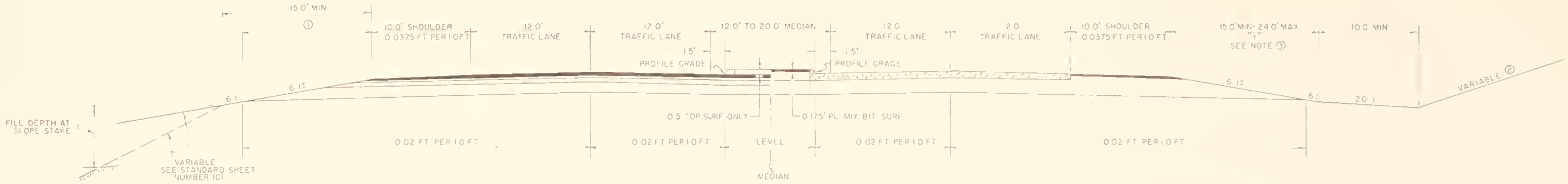
TYPICAL SECTION NO. 4
FOR MEDIANS OF 14'

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO 105

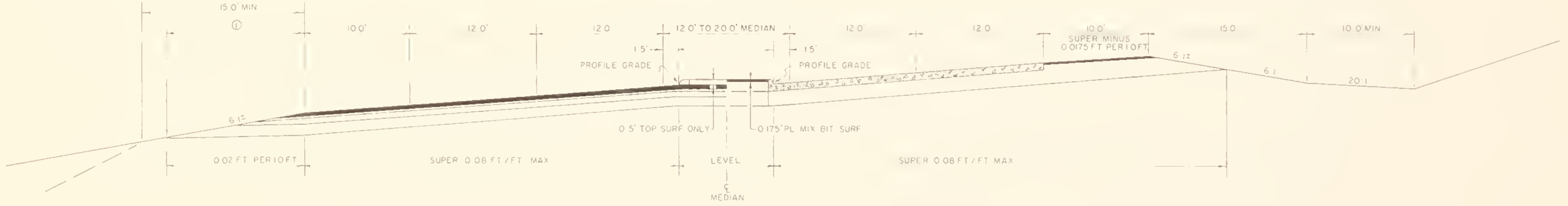
TANGENT SECTION



TYPICAL BITUMINOUS SECTION

TYPICAL CONCRETE SECTION

CURVE SECTION ④



TYPICAL BITUMINOUS SECTION

TYPICAL CONCRETE SECTION

NOTES

① COMPUTE SUBGRADE WIDTHS TO NEAREST FOOT

② IN NORMAL CUT SECTIONS, SEE STANDARD SHEET NUMBER 101 FOR BACKSLOPE IN ROCK CUT SECTIONS, SEE STANDARD SHEET NUMBER 110 FOR DITCH WIDTH AND BACKSLOPE

③

SURFACE THICKNESS AT FINISHED SHOULDER	"Y" IN FEET
0 - 1 35'	15
1 40 - 1 50'	16
1 55 - 1 65'	17
1 70 - 1 80'	18
1 85 - 1 95'	19
2 00 - 2 10'	20
2 15 - 2 25'	21
2 30 - 2 40'	22
2 45 - 2 55'	23
2 60 - 2 70'	24
2 75 & OVER	*

* SPECIAL DESIGN SUBJECT TO HEADQUARTERS APPROVAL

④ SEE STANDARD SHEET NUMBER 301 FOR SUPER-ELEVATION

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

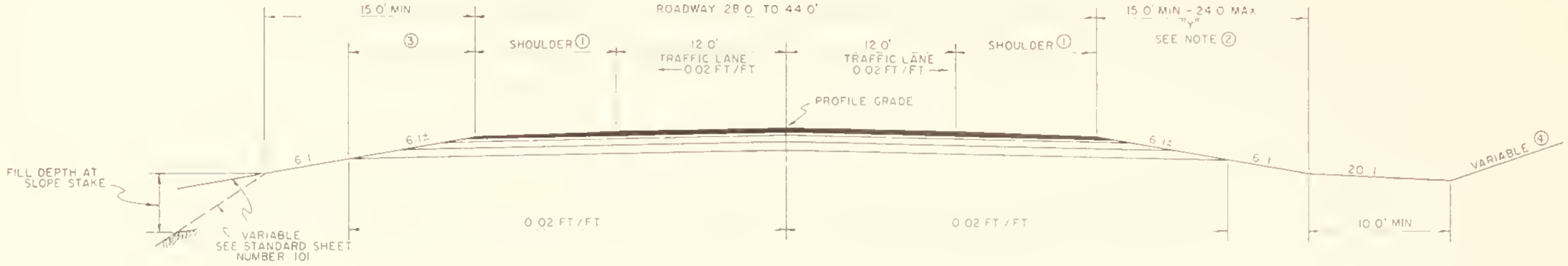
TYPICAL SECTION NO 5
FOR CURBED MEDIANS
OF 12' TO 20'

APPROVED

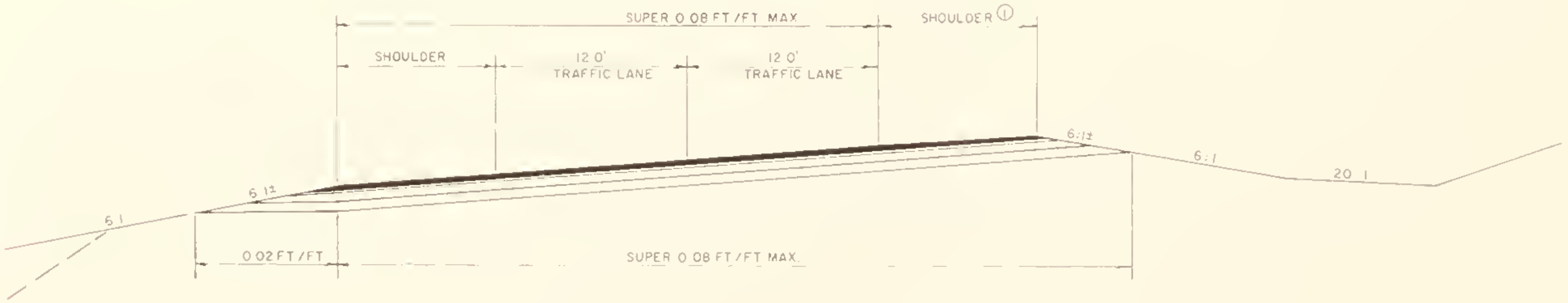
STATE HIGHWAY ENGINEER

STANDARD SHEET NO 106

TANGENT SECTION



CURVE SECTION⑤



NOTES

①

ROADWAY WIDTH, FEET	SHOULDER WIDTH, FEET	SHOULDER SLOPE FT/FT	
		TANGENT	CURVE
28	2	0.02	SUPER
30	3	0.02	SUPER
34	5	0.02	SUPER
36	6	0.02	SUPER
40	8	0.0356	SUPER - 0.0156
44	10	0.0325	SUPER - 0.0125

②

SURFACE THICKNESS AT FINISHED SHOULDER	"Y" IN FEET
0 - 1.35'	15
1.40 - 1.50'	16
1.55 - 1.65'	17
1.70 - 1.80'	18
1.85 - 1.95'	19
2.00 - 2.10'	20
2.15 - 2.25'	21
2.30 - 2.40'	22
2.45 - 2.55'	23
2.60 - 2.70'	24
2.75 & OVER	*

* SPECIAL DESIGN SUBJECT TO HEADQUARTERS APPROVAL

③ COMPUTE DISTANCE TO NEAREST FOOT

④ IN NORMAL CUT SECTIONS, SEE STANDARD SHEET NUMBER 101 FOR BACKSLOPE. IN ROCK CUT SECTIONS, SEE STANDARD SHEET NUMBER 110 FOR DITCH WIDTH AND BACKSLOPE.

⑤ SEE STANDARD SHEET NUMBER 301 FOR SUPERELEVATION

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

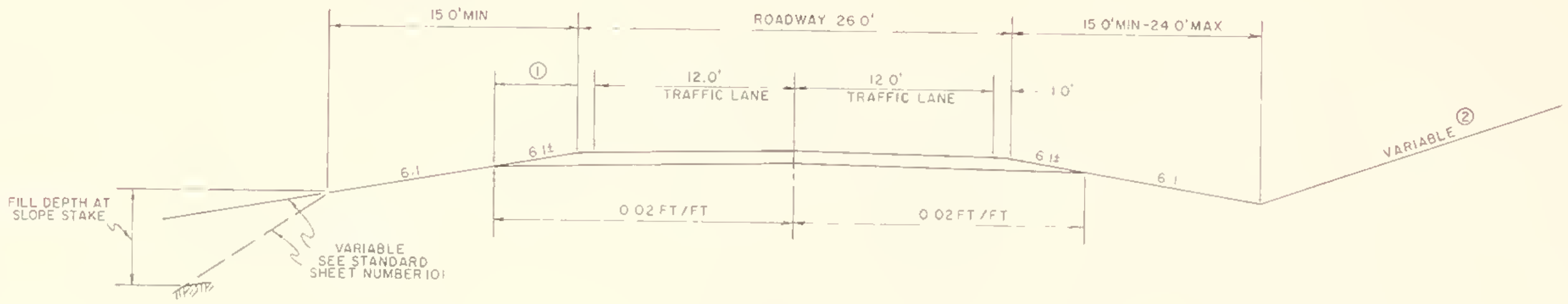
TYPICAL SECTION NO. 6
FOR 2-LANE HIGHWAYS WITH
ROADWAY WIDTHS FROM 28' TO 44'

APPROVED

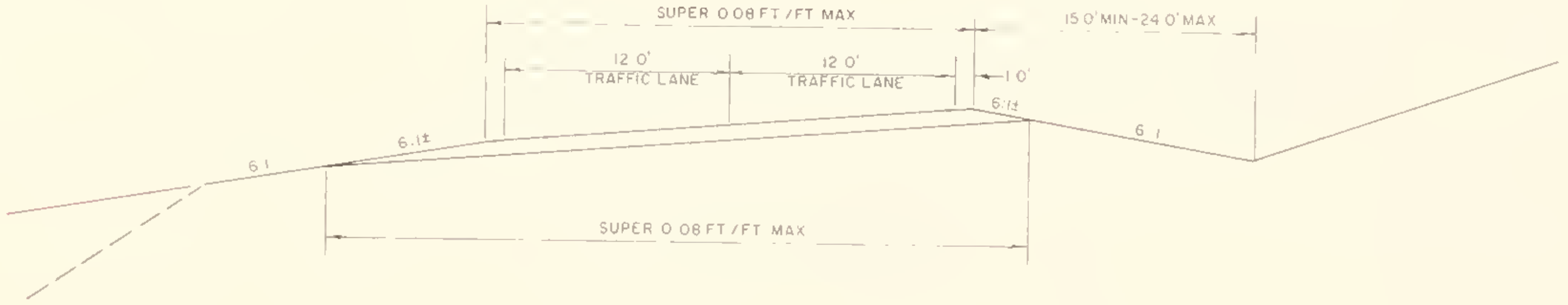
STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 107

TANGENT SECTION



CURVE SECTION ③



NOTES

① COMPUTE DISTANCE TO NEAREST FOOT

② IN NORMAL CUT SECTIONS, SEE STANDARD SHEET NUMBER 101 FOR BACKSLOPE. IN ROCK CUT SECTIONS, SEE STANDARD SHEET NUMBER 110 FOR DITCH WIDTH AND BACKSLOPE

③ SEE STANDARD SHEET NUMBER 301 FOR SUPERELEVATION

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

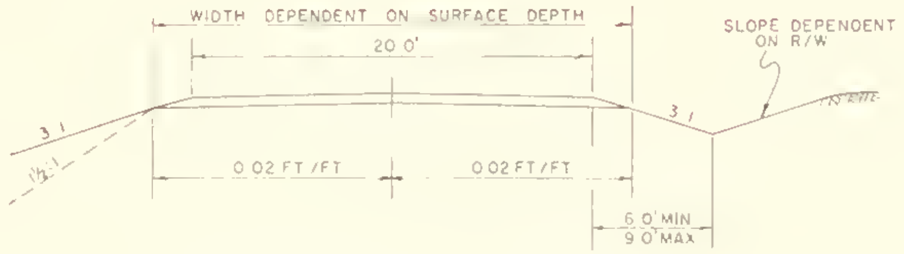
TYPICAL SECTION NO. 7
FOR 2-LANE HIGHWAY WITH
26' ROADWAY

APPROVED

STATE HIGHWAY ENGINEER

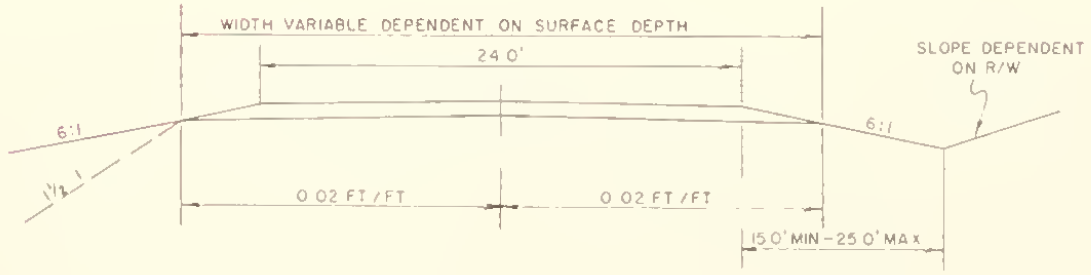
STANDARD SHEET NO. 108

TYPICAL SECTION NO. 8



FOR PRIVATE USE ACCESS ROADS
WITH CURRENT ADT OF 10 OR LESS

TYPICAL SECTION NO. 9



FOR PUBLIC USE FRONTAGE ROAD
WITH CURRENT ADT OF 50 OR LESS

NOTES

PUBLIC USE FRONTAGE ROADS WITH A CURRENT ADT OF MORE THAN 50 WILL BE DESIGNED ACCORDING TO THE STANDARDS FOR PRIMARY AND SECONDARY HIGHWAYS

DOZER TRAILS WILL BE CONSTRUCTED TO THE WIDTH OF EQUIPMENT USED.

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TYPICAL SECTIONS NOS 8 & 9
FRONTAGE ROADS
FOR CURRENT ADT OF 50 OR LESS

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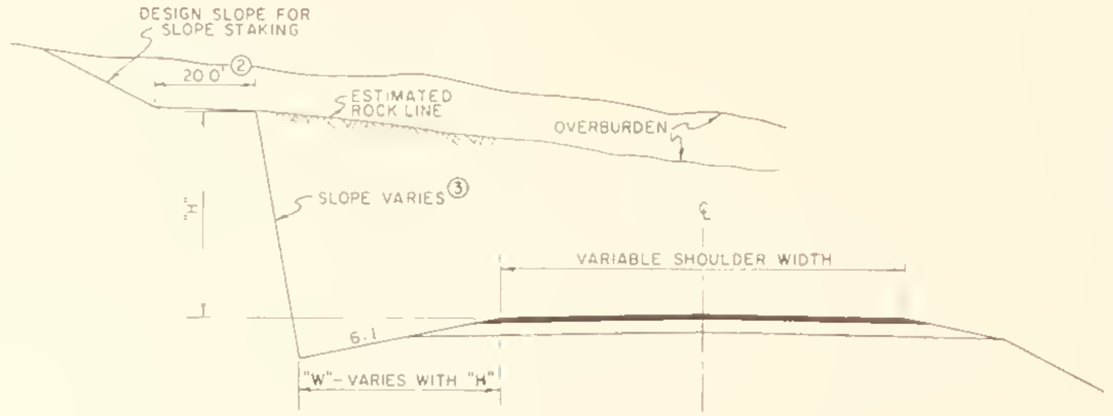
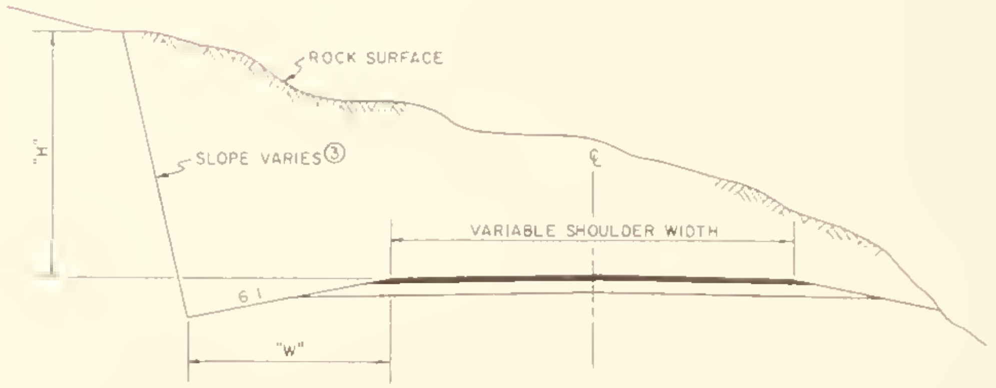
STATE HIGHWAY ENGINEER

STANDARD SHEET NO 109

TYPICAL CUT SECTION IN ROCK ①
COVERED WITH COMMON OVERBURDEN



TYPICAL CUT SECTION IN ROCK ①



NOTES

① TO BE USED IN ALL ROCK CUTS WHERE BACKSLOPES ARE STEEPER THAN 1½:1

② OFFSET IS FOR SLOPE STAKING ONLY TO MINIMIZE RESLOPING DUE TO VARIATIONS IN ESTIMATED TOP OF ROCK. THERE IS NO INTENTION TO PROVIDE A BENCH AT TOP OF ROCK

③

"H"	"W"	● SLOPE
0-25'	15'	VERTICAL
25-60'	20'	¼:1
60-100'	25'	¼:1
OVER 100'	30'	¼:1

● SLOPES WILL BE AS STEEP AS THE ROCK STRUCTURE WILL PERMIT, NOT TO EXCEED THOSE SHOWN ABOVE

IF BENCHES ARE USED "W" DISTANCE, FROM THE ABOVE TABLE, MUST CORRESPOND WITH "H" DISTANCE MEASURED TO THE LOWEST BENCH. ALL BENCHING REQUIRES PRIOR APPROVAL

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

STANDARD CUT SECTION
IN ROCK

APPROVED
STATE HIGHWAY ENGINEER

STANDARD SHEET NO 110

SOURCE OF INFORMATION

Chapter Two

SOURCES OF INFORMATION

Many different kinds of information must be available to a highway designer. Some information is related to a specific project -- other information is related to all projects.

This manual is a principal source of information providing general guidance on design policies and procedures. Other sources of information to be used by designers are set forth below. They include field survey information, books, manuals, memorandums and related special engineering services.

FIELD SURVEY INFORMATION

Field survey information provides the basic data needed for the design of specific projects. The following field survey information normally is received for use throughout the design process:

- Plotted hardshells
- Design mapping as available from the Photogrammetric Unit
- Soils profiles showing the locations of drill logs and soils classifications
- Topsoil availability forms
- Shrinkage factor recommendations
- Local water data and geologists' recommendations.
- Existing drainage and drainage recommendations
- Irrigation and access recommendations
- Telephone and electric service information
- Recommended gradelines
- Narrow-band ownership maps
- Bridge situation sheets
- Survey notes, including transit notes, Level data, topography notes, section ties, cross-section data and drainage data.

BOOKS, MANUALS AND MEMORANDUMS

Several books, manuals and memorandums contain information needed by designers. These sources of information are cited below.

Department Publications

The following items are published by the Montana Department of Highways:

- Standard Specifications

  The book of "Standard Specifications for Road and Bridge Construction" describes work to be performed under various contract bid items.

- Supplemental Specifications

  A pamphlet of Supplemental Specifications sets forth the current amendments -- additions, deletions and revisions-- to the Standard Specifications.

- Standard Drawings

  The book of Standard Drawings is a compilation of standardized details frequently used in highway design. As needed, the designer will select specific Standard Drawings to be included with each set of contract plans.

- Road Design Management Manual

  The Road Design Management Manual describes the work flow for the highway design process, the relationships between organizational units and procedures for planning and scheduling work.

- Average Bid Price Summaries

  Average Bid Price Summaries set forth the average unit bid prices for various contract pay items. These prices will be used as the bases for preparing cost estimates. Average Bid Price Summaries are revised ond published semi-annually by the Contract Plans Unit.

- Policy Memorandums

  New design policies often will be set forth in Department policy memorandums. Designers will receive copies of these memorondums. Periodically those policies will be incorporated in revisions to the Design Manual.

AASHO Publications

The American Association of State Highway Officials has published several reference sources containing background information and derivations for design criteria. The AASHO publications used most often are A Policy on the Geometric Design of Rural Highways, commonly referred to as the "AASHO Blue Book," and A Policy on the Geometric Design of Urban Highways, commonly referred to as the "AASHO Red Book". Other publications containing more detailed guidance on specific areas of highway design are available in Department files.

FHWA Publications

The Federal Highway Administration's Policies and Procedures Memorondums (PPM's) set forth specific policies and procedures related to Federol-Aid highway projects. Complete sets of current PPM's, IM's (Instructional Memorandums) and CM's (Circular Memorandums) are available in Department files.

FAA Publications

The Federal Aviation Administration issues regulations governing the construction of objects affecting navigable airspace. These regulations are included in "Part 77, Federal Aviation Regulations" and are referred to in Chapter Twelve.

Supplier Publications

Literature on special design problems usually is available from suppliers of construction materials. Such literature may be usefull in the design of special culverts, retaining walls and other items.

ENGINEERING SERVICES

The highway designer frequently will encounter design problems which require guidance and assistance of persons with specialized training and competence. The following organizations within the Department are available to designers for special engineering services. The relationships between the designers and these units are defined in the Road Design Management Manual.

- Hydraulics Unit
- Traffic Unit
- Environmental Unit
- Photogrammetric Unit
- Contract Plans Unit
- Surfacing Unit
- Bureau of Bridge Design
- Bureau of Right-of-Way
- Project Control Section
- Public Hearing Unit

HORIZONTAL ALIGNMENT

Chapter Three

HORIZONTAL ALIGNMENT

GENERAL CONSIDERATIONS

Criteria for the horizontal alignment of highways are directed to providing vehicle operation at consistent speeds with safety and with consideration for aesthetic and economic factors. For the most part this is done through use of design speed as an overall control.

Factors such as traffic volumes, terrain conditions and construction costs will influence decisions on appropriate design speed. When design speed is established, it is essential that the characteristics of the horizontal alignment assure continuous safe operation at that speed.

Alignment criteria involve two basic considerations:

1. The degree of curvature.
2. Superelevation of curves.

In the design of highway curves it is necessary to establish the proper relationship between design speed, degree of curvature and superelevation.

Usually, horizontal alignment will be established in the field by location engineers in accordance with controlling design standards. It is the responsibility of the designer to check the alignment and verify compliance with standards.

STANDARDS FOR CURVATURE

Maximum Degree of Curvature

The maximum degree of curvature is limited by the design speed of the highway and the maximum superelevation permitted. In Montana, the maximum superelevation rate is 0.08 ft. per 1.0 ft. With this rate of slope, the sharpest permissible curve for each design speed is as follows:

Design Speed	Maximum Degree of Curve
40 m.p.h.	12° 30'
50 m.p.h.	7° 30'
60 m.p.h.	5° 00'
70 m.p.h.	3° 30'

Under no condition should curves be sharper than those shown above.

Desirable Curvature

Try to avoid the use of maximum-degree curves, unless they are economically necessary due to topographical conditions.

For small deflection angles, curves should be long enough to avoid the appearances of kinks. Curves should be at least 500 feet long for a central angle of 5 degrees, and the minimum length should be increased 100 feet for each 1-degree decrease in the central angle.

Use of Spiral Transitions

For rural areas, all curves of 1° 30' or sharper must include spiral transitions as indicated on Standard Sheet No. 301. For urban areas, all curves should be simple, regardless of the degrees of curvature.

GENERAL ALIGNMENT CRITERIA

In addition to those alignment standards related to design speed, consideration should be given to the following general criteria:

- Avoid sharp curves at the ends of long tangents.
- Avoid sudden changes from easy curvature to sharp curvature.
- Avoid compound curvature -- adjacent horizontal curvatures with no tangent length separating them.
- Avoid sharp reverse curvature. Provide adequate distance for superelevation runoff.
- Avoid broken-back curvature -- two curves in the same direction separated by a short tangent length. Use a single longer curve for this situation.

SUPERELEVATION

Superelevations must be provided in horizontal curves to permit vehicles to traverse them safely without excessive horizontal forces. The amount of each superelevation needed depends on the sharpness of the curve and the speed of the vehicle.

For urban areas, superelevations must be designed to fit individual conditions.

For rural areas, superelevations must be designed according to Standard Sheet No. 301.

Rate of Superelevation

In Montana, the maximum superelevation rate is 0.08 ft. per ft. (A slope of 0.08' vertical to 1.0' horizontal.)

Standard Sheet No. 301 shows the proper rate of superelevation for each of the various combinations of degree of curvature and design speed.

Transitions

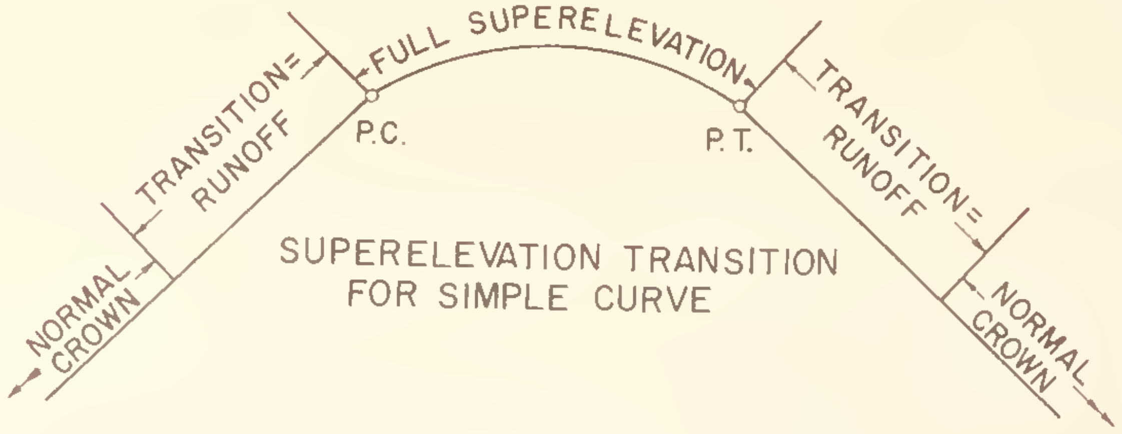
For simple curves, the transition from normal crown to full superelevation will occur entirely on the tangents preceding the P.C. and following the P.T. This transition distance is defined as "runoff distance", and the required length depends on design speed, number of lanes and degree of curvature as indicated on Standard Sheet No. 301.

For spiral curves, the transition from normal crown to full superelevation will occur partly on the tangents preceding the T.S. and following the S.T. and along the entire lengths of the spirals. The transition distances on the tangents are defined as "runout distances". Each runout distance will be thot necessary to raise the outside traffic lanes from their normal crown slope to a flat position (no crown slope), but in no case will the runout distance be less than 100 feet.

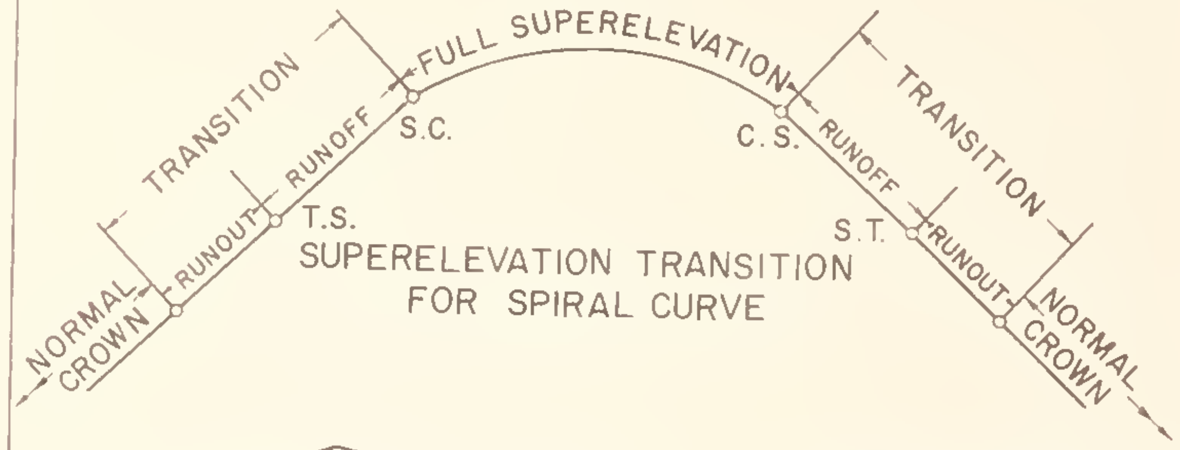
The transition distances on the spirals are defined as "runoff distances", and the required lengths depend on design speed, number of lanes ond degree of curvature as indicated on Standard Sheet No. 301.

On 4-lane divided highways where both roadways have the same profile grade elevation, superelevation will be rotated about the profile grade. On 2-lane highways and on 4-lane highways where the roadways have different profile grade elevations, superelevation on each roadway will be rotated about the inside edge of the traffic lane at an elevation of profile grade less normal crown.

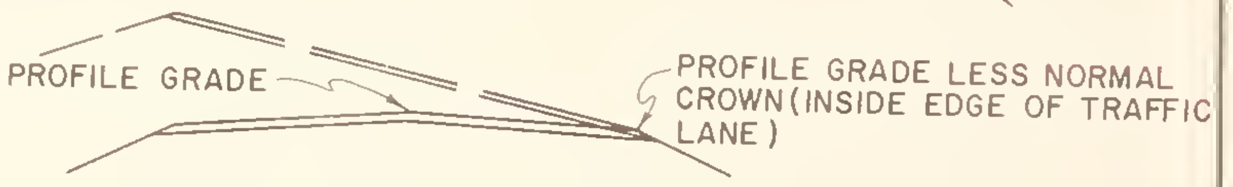
Degree of Curvature	40 M.P.H.			50 M.P.H.			60 M.P.H.			70 M.P.H.		
	Crown Slope	Runoff Distance, Ft.		Crown Slope	Runoff Distance, Ft.		Crown Slope	Runoff Distance, Ft.		Crown Slope	Runoff Distance, Ft.	
	Ft/Ft	2-lane	4-lane	Ft/Ft	2-lane	4-lane	Ft/Ft	2-lane	4-lane	Ft/Ft	2-lane	4-lane
0° 15'	NC	0	0	NC	0	0	NC	0	0	NC	0	0
0° 30'	NC	0	0	NC	0	0	RC	200	200	RC	200	200
0° 45'	NC	0	0	RC	150	150	.02	200	200	.03	200	200
1° 00'	RC	150	150	.02	150	150	.03	200	200	.04	200	200
1° 30'	.02	150	150	.03	150	150	.04	200	200	.05	200	250
2° 00'	.03	150	150	.04	150	150	.05	200	250	.06	200	300
2° 30'	.03	150	150	.04	150	200	.06	200	250	.07	250	350
3° 00'	.04	150	150	.05	150	200	.07	200	300	.08	250	350
3° 30'	.04	150	150	.06	150	250	.07	200	300	Degree Max.=3° 30'		
4° 00'	.05	150	150	.06	150	250	.08	250	350	.08	250	350
5° 00'	.06	150	200	.07	200	300	Degree Max. =5° 00'					
6° 00'	.06	150	200	.08	200	300	.08	250	350			
7° 00'	.07	150	250	.08	200	300						
8° 00'	.07	150	250	Degree Max. =7° 30'								
9° 00'	.08	200	250	.08	200	300						
10° 00'	.08	200	250									
11° 00'	.08	200	250									
12° 00'	.08	200	250									
	Degree Max.=12° 30'											
	.08	200	250									



SUPERELEVATION TRANSITION FOR SIMPLE CURVE

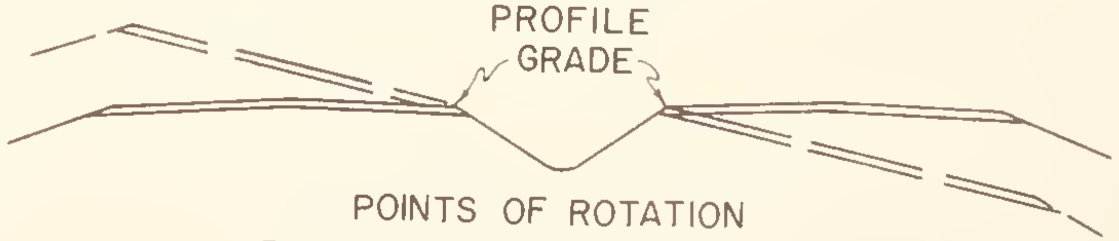


SUPERELEVATION TRANSITION FOR SPIRAL CURVE


PROFILE GRADE
PROFILE GRADE LESS NORMAL CROWN (INSIDE EDGE OF TRAFFIC LANE)

POINT OF ROTATION

FOR 2-LANE HIGHWAYS AND 4-LANE DIVIDED HIGHWAYS WITH DIFFERENT PROFILE GRADE ELEVATIONS.



POINTS OF ROTATION

FOR 4-LANE DIVIDED HIGHWAYS WITH SAME PROFILE GRADE ELEVATION.

NOTES

Spirals shall be used on all curves 1° 30' or greater with spiral lengths equal to the above lengths for runoff.

NC – Normal Crown Section

RC – Remove adverse crown, superelevate at normal crown slope.

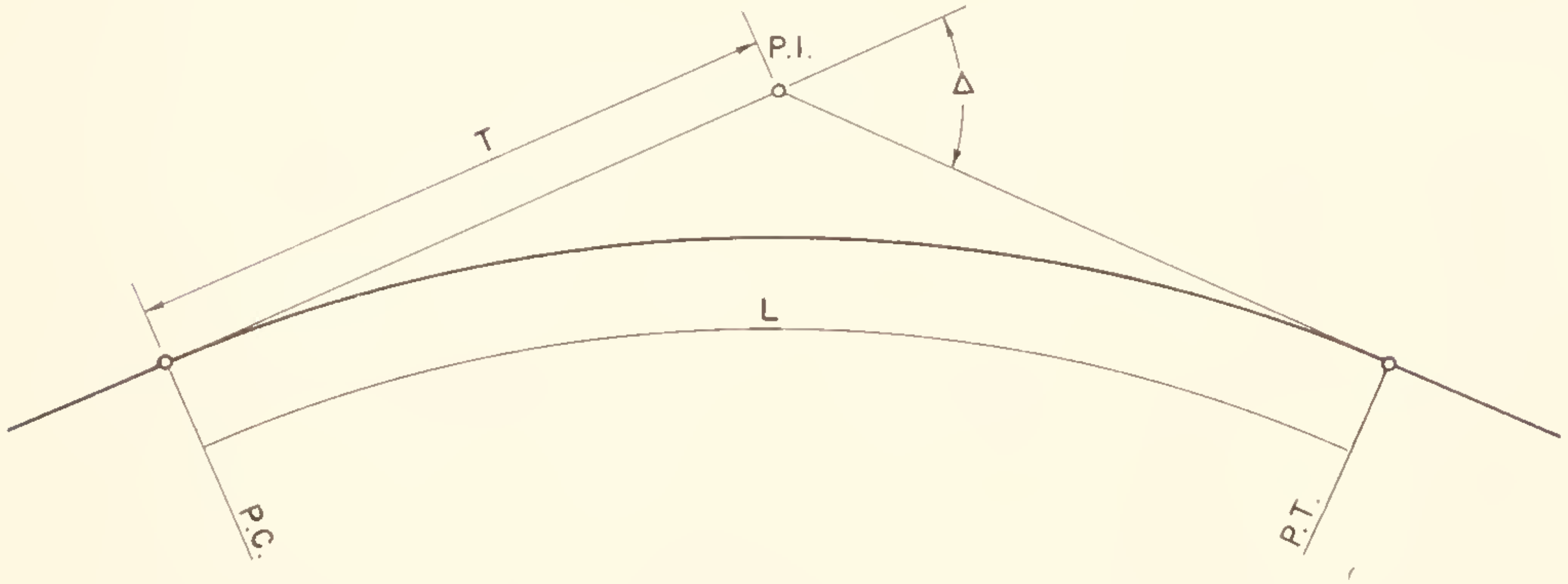
Minimum Runout Distance = 100 Ft.

REVISIONS		MONTANA DEPARTMENT OF HIGHWAYS
DATE	BY	STANDARD SUPERELEVATION
		APPROVED STATE HIGHWAY ENGINEER
		STANDARD SHEET NO. 301

COMPUTATION OF HORIZONTAL CURVES

Simple Curves

Computations of simple curves involve the relationships expressed in the formulae below. Usually the P.I. station, the deflection angle (Δ) and the degree of curvature (D) are established. The remaining curve data must be computed.



P.I. = Point of Intersection
P.C. = Point of Curvature
P.T. = Tangent Length
T = Tangent Length (ft.)
[1] T_1 = Tangent Length (ft.) of 1° curve for Δ degrees
D = Degree of Curvature
L = Length of Curve (ft.)
Δ = Deflection Angle
R = Radius of Curve (ft.)

$$T = \frac{T_1}{D}$$

$$L = \frac{100\,\Delta}{D}$$

$$R = \frac{5729.58}{D}$$

P.C. Sta. = P.I. Sta. -T

P.T. Sta. = P.C. Sta. + L

When computing lengths of curve elements, D and Δ should be expressed in degrees and decimals of degrees and corried to four places past the decimal point. When recording curve data on the plans, D and Δ should be expressed in degrees and minutes, and distances (T, L, R and stationing) should be shown to the nearest one-tenth of a foot (0.1').

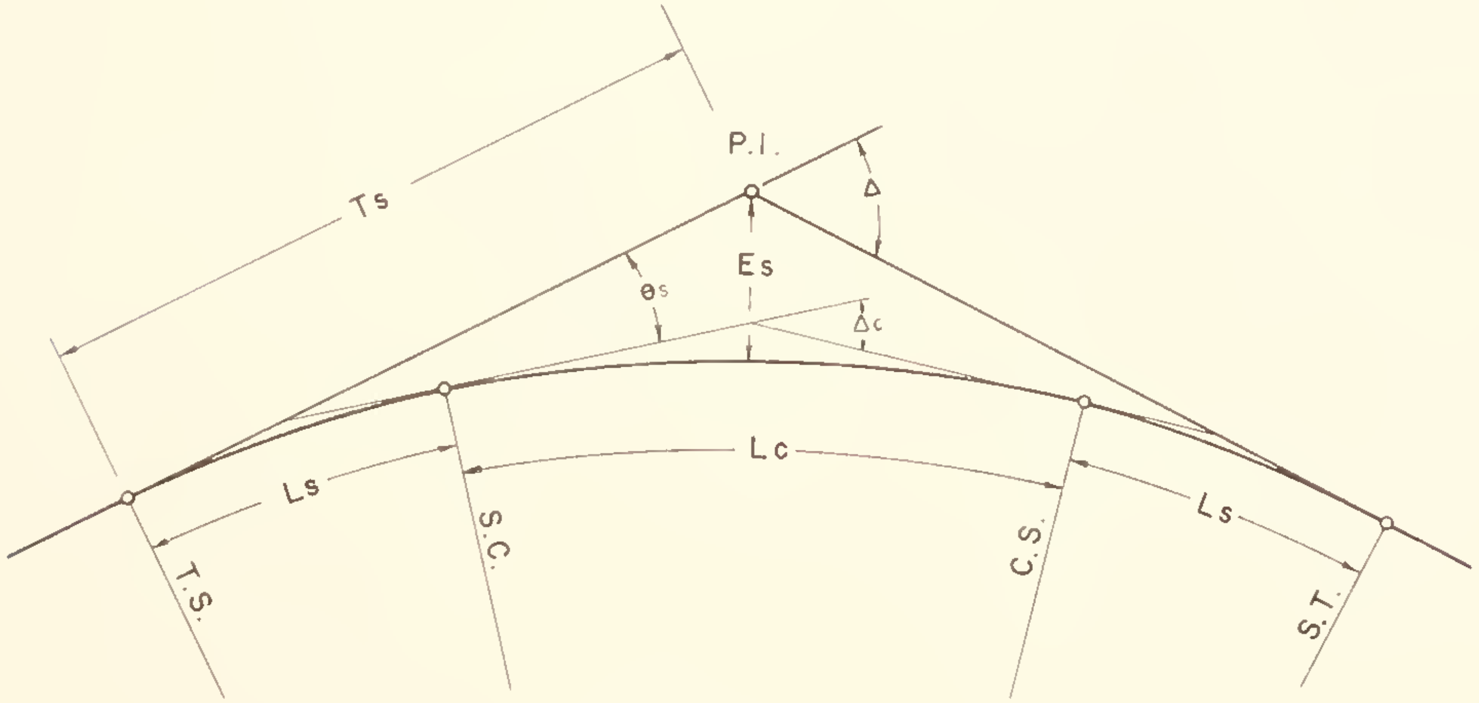
---

[1] Tangent lengths of 1° curves can be obtained from the section on "Functions of a One Degree Curve" in the *Highway Engineer's Handbook* by Harger and Bonney.

Spiral Curves

Computation of spiral curves involves the relationships expressed in the formulae below. Usually the P.I. station, the deflection angle (Δ) and the degree of curvature (D_c) are established. The spiral length (L_s) depends on the degree of curvature, the design speed and the number of traffic lanes. Select the appropriate spiral length from Standard Sheet No.301. Based on the values of Δ, L_s and D_c, the tangent length (T_s) and the external distance (E_s) can be read directly from "Table IV" of Transition Curves for Highways by Joseph Barnett.

The remaining curve data must be computed.



P.I. = Point of Intersection
T.S. = Tangent to Spiral
S.C. = Spiral to Curve
C.S. = Curve to Spiral
S.T. = Spiral to Tangent
Θ_s = Spiral Deflection Angle
Δ_c = Circular Curve Deflection Angle
Δ = Deflection Angle
D_c = Degree of Curvature
L_s = Length of Spiral (ft.)
L_c = Length of Circular Curve (ft.)
R = Radius of Circular Curve (ft.)
E_s = External Distance (ft.)
T_s = Tangent Length (ft.)

$$\Theta_s = \frac{L_s\ D_c}{200}$$

$$\Delta_c = \Delta - 2\,\Theta_s$$

$$L_c = \frac{100 \times \Delta_c}{D_c}$$

$$R = \frac{5729.58}{D_c}$$

$$\text{T.S. Sta.} = \text{P.I. Sta.} - T_s$$

$$\text{S.C. Sta.} = \text{T.S. Sta.} + L_s$$

$$\text{C.S. Sta.} = \text{T.S. Sta.} + L_s + L_c$$

$$\text{S.T. Sta.} = \text{T.S. Sta.} + 2L_s + L_c$$

When computing lengths of curve elements, D_c and Δ_c should be expressed in degrees and decimals of degrees carried to four places past the decimal point. When recording curve data on the plans, D_c, Δ_c, Δ and Θ_s should be expressed in degrees and minutes. All distances (L_s, L_c, R, E_s and T_s and stationing) should be shown to the nearest one-tenth of a foot (0.1').

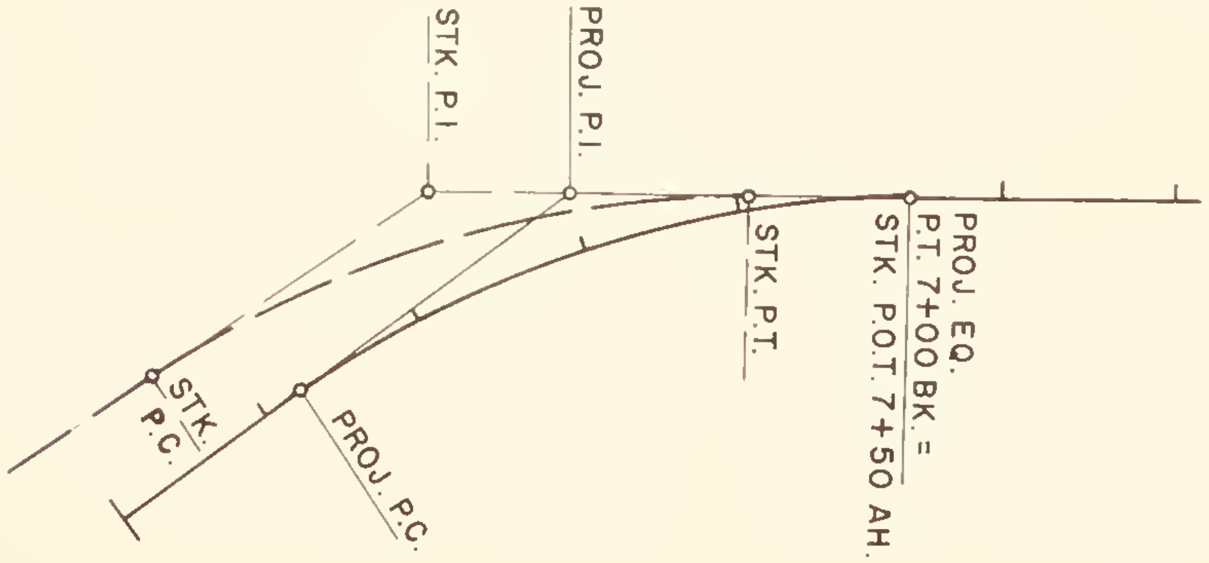
EQUATIONS

General Considerations

An equation should equate two station numbers: one that is correct when measuring on the line back of the equation and one that is correct when measuring on the line ahead of the equation. Equations should be used where stationing is not continuous throughout a project -- as discussed below.

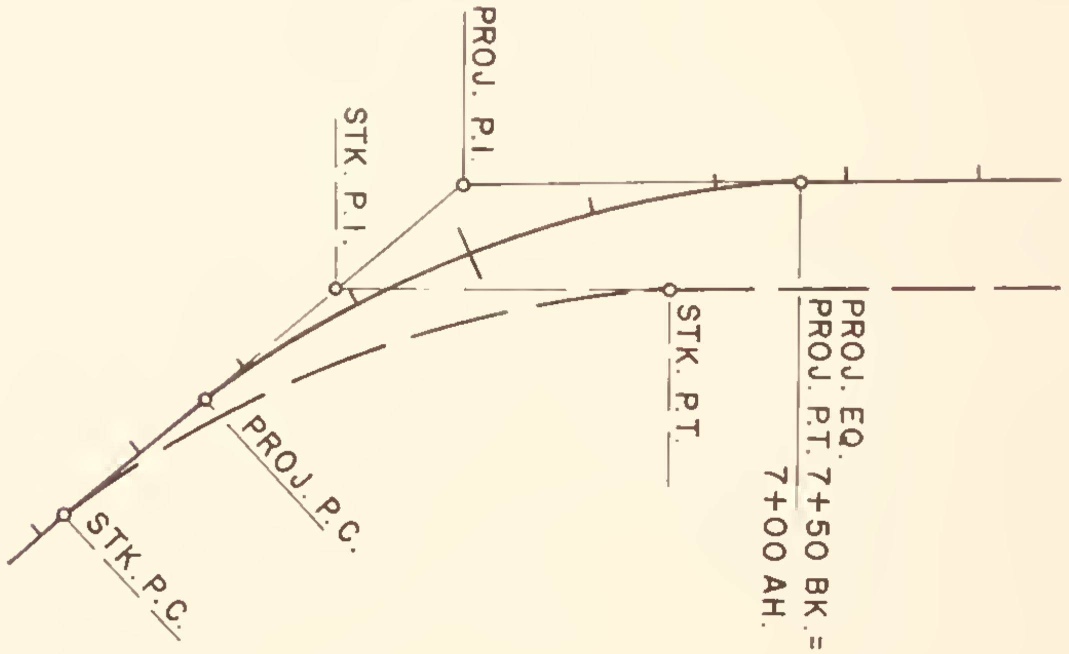
Locations of Equations

Equations should be computed where projected lines become coincident with staked lines. This situation is shown below:



EQUATION WHERE PROJECTED
LINE BECOMES COINCIDENT
WITH STAKED LINE

Equations also should be computed in certain cases where projected lines become parallel with staked lines. If the projected line remains parallel with the staked line for a considerable distance representing numerous cross sections, it is more convenient to compute an equation than to restation the cross sections. An example of such an equation is shown below:



EQUATION WHERE PROJECTED
LINE BECOMES PARALLEL WITH
STAKED LINE

VERTICAL ALIGNMENT

VERTICAL ALIGNMENT

GENERAL CONSIDERATIONS

Vertical alignments of highways will be designed in the office and recorded initially on working profiles. The following factors are principal design considerations.

- Established geometric standards
- Balanced earthwork quantities
- Special considerations

VERTICAL ALIGNMENT STANDARDS

Maximum Grades

The tables of Geometric Design Standards show the maximum grades for any highway identified in terms of the design speed of the highway and the general terrain of the highway location (flat, rolling or mountainous).

Grades steeper than shown in the table can be used only with prior approval of the Administrator, Preconstruction Division.

Minimum Grades

Flat grades, if needed, can be used on uncurbed pavements on high fills.

In cut sections with ditches or curbed pavements the grade should be at least 0.2%.

Stopping Sight Distances

Sight distance can become restricted when grade changes are introduced in vertical alignment. This occurs not only on crest vertical curves, but also on sag vertical curves at night when headlight distance is reduced.

Criteria have been established for absolute minimum sight distances required for a vehicle to stop safely after the driver sees a hazardous object on the road surface. The required stopping sight distance varies for different design speeds. The actual sight distance provided varies with the amount of change in grade and the length of the vertical curve introduced.

The tables below show desirable minimum and absolute minimum stopping sight distances for each design speed:

DESIRABLE MINIMUM STOPPING SIGHT DISTANCE

Design Speed, M.P.H.	Stopping Sight Distance, Ft.	K Value Crest V.C.	K Value Sag V.C.
40	300	65	60
50	450	145	100
60	650	300	155
70	850	515	215

ABSOLUTE MINIMUM STOPPING SIGHT DISTANCE

Design Speed, M.P.H.	Stopping Sight Distance, Ft.	K Value Crest V.C.	K Value Sag V.C.
40	275	55	55
50	350	85	75
60	475	160	105
70	600	255	145

For any given situation, the minimum permissible length of a vertical curve (expressed in feet) is found by multiplying the algebraic difference in grades (%) by the "K" value for the appropriate design speed. A shorter vertical curve will not provide adequate stopping sight distance.

Passing Sight Distance

Similar criteria have been established for sight distance required to safely overtake and pass a vehicle going in the same direction of travel on a 2-lane, 2-way highway. Minimum passing sight distances and "K" values for crest vertical curves are shown in the following table:

MINIMUM PASSING SIGHT DISTANCE		
Design Speed, M.P.H.	Minimum Passing Sight Distance, Ft.	K Value Crest V.C.
40	1500	686
50	1800	985
60	2100	1340
70	2500	1895

The length (in feet) of a vertical curve needed to provide required sight distance for passing is determined by multiplying the algebraic difference in grades (%) by the appropriate "K" value.

Do not be misled by these criteria. There are conditions that make it impracticable to provide adequate passing sight distance at every vertical curve. In some instances it will be necessary to concede that certain areas be striped for "no passing." When this happens, the no-passing zone should be as short as practicable to assure that passing can be permitted on a greater portion of the total project length. It is not sensible to design an extremely long vertical curve which does not provide passing sight distance -- as this unnecessarily lengthens the no-passing zone.

Lengths of Vertical Curves

The required length of a vertical curve usually is influenced by the amount of change of grade (algebraic difference) occurring at the P.I. The curve must be long enough to provide the stopping sight distance shown in the design standards.

Generally, vertical curves should be designed according to desirable lengths. Where stopping sight distance is not a factor vertical curves should normally be 1000 feet long. With very large algebraic differences in grades, vertical curves may have to be longer than 1000 feet. Always check to make sure that stopping sight distance is provided.

BALANCING EARTHWORK

Projects will be designed to produce balanced earthwork unless particular features dictate otherwise. Excavated material from within the limits of the regular typical section should be the amount needed to construct embankments to the designed grade.

To attain balanced earthwork, grade adjustments generally are preferable to ditch widening. In some instances where grade controls are critical, it will not be possible to adjust grades to attain balanced earthwork. Provisions must be made to borrow or waste material as necessary.

SPECIAL CONSIDERATIONS

Field Recommendations

At the time of the field location survey, the location engineer reviews the ground line profile data and develops recommendations for certain grade line controls. Notations are placed on the working profile indicating the recommended grade line to be established across low flats, lake beds, sloughs, creek bottoms, important intersecting roads, and in front of improved property, at places subject to snow trouble, and at other places requiring special attention.

The designer should review and consider these recommendations and establish a tentative grade line on the working profile consistent with the design standards and the guidelines in this manual.

Ties with Adjoining Projects

A smooth transition is needed with adjoining projects. Adequate space should be provided on the working profile to plot connecting ground lines and grades for a distance of at least 2000 feet. Connections with the P.T.W. on new projects should be compatible with the design speed of the new project.

A connecting grade should be established which satisfactorily adjoins the existing alignment and which can be utilized when the adjoining project is reconstructed.

Smooth Grade Line

Changes in grade should be gradual and consistent with the type of highway and the character of terrain. Numerous breaks and short lengths of grade tangents should be avoided.

Hidden Dips

Sudden dips of the profile on a relatively straight alignment are hazardous during passing maneuvers. When practicable, maintain passing sight distance by using flatter grades and higher elevations through the low spots.

Broken-Back Grade Lines

A broken-back grade line -- two vertical curves in the same direction separated by a short (500 ft.) section of tangent grade -- should be avoided. This is particularly important in sags where the full view of both vertical curves is not pleasing.

This type of grade line may be avoided by joining the vertical curves or replacing them with a single curve of greater length.

Relationship with Horizontal Curvature

Lengths of vertical curves and grades should be influenced by the lengths of the horizontal elements on which they are superimposed. The following guidelines should be considered:

- Horizontal curvature should lead vertical curvature and remain somewhat longer than the latter. Visually, they should be similar in length.

- Sharp horizontal curvature should not be introduced at the crest or at the low point of a vertical curve.

- The locations of vertical curve P.I.'s and horizontal curve P.I.'s should roughly coincide.

Railroad Grade Crossings

The finished surface grade line must match the elevation of the top of the rails at railroad grade crossings. The skew of the crossing and the gradient of the rails may in some instances necessitate minor warping of the surface at the crossing.

Drainage Structures

Pipe culverts will have a minimum of 2 feet of cover, measured from the finished shoulder to the top of the pipe.

Grade design in the vicinity of box culverts and bridges should be coordinated with bridge design to ensure adequate high water clearance.

Soils Conditions

Areas of poor or wet soil conditions will be indicated in field recommendotions, along with recommendations for minimum fill heights. These controls should influence design of the grade line.

Snow Drift Areas

The problem of drifting snow on the highway surface can be minimized by providing wide ditches with flat slopes.

Where wide ditches with flat slopes are not provided, it is desirable to have the grade a minimum of 2 feet above the natural ground on the windward side of the highway. Take prevailing winds into consideration.

URBAN GRADE DESIGN

The design of vertical alignment on urban projects frequently involves special considerations. The guidelines below should be followed.

Grades

Spline curves are helpful in laying grades in urban areas where it is necessary to meet numerous elevations in relatively short distances. Profile grades should represent gutter lines wherever possible.

The gutter lines can be shown as spline curves, with the beginning and end of each spline curve tied into the grade lines. Elevations along spline curves should be shown at 20- foot intervals on the profile.

Vertical Curves

Vertical curves are not required where the algebraic difference in grades is less than 0.2%. Curves must be long enough to ensure minimum stopping sight distance.

Where possible, P.I.'s should be located at or near the centerlines of cross streets.

Surface Drainage

Grade lines should be established to make the top of curb coincide with the natural ground. This permits adjacent surface drainage to flow into the gutter for controlled outlet at specified locations.

Try to avoid grades that impound water back of the curb.

Gutters should be placed on a grade of at least 0.2% for drainage. Avoid level sections of gutter or low spots in the gutter that do not have outlets. Where surface drainage is provided across intersecting streets, the drainage depression will have a minimum radius of 12 feet.

Existing Roadside Development

Occasionally, a situation will arise where extensive development exists on both sides of the street, and the ground or development on one side is higher than the other. In this situation, a grade line may fit the development on one side but result in extensive property damage to the development on the other side. An unsymmetrical section may be used. The total drop from crown point to gutter will be greater than normol on one side and less than normal on the other side.

The grade line must be placed so that the curb and gutter on the project will meet the curb and gutter existing on intersecting cross-streets.

GRADE COMPUTATIONS

Gradients

Normally, grades will be computed and recorded to the nearest one-hundredth of a percent (two decimal places).

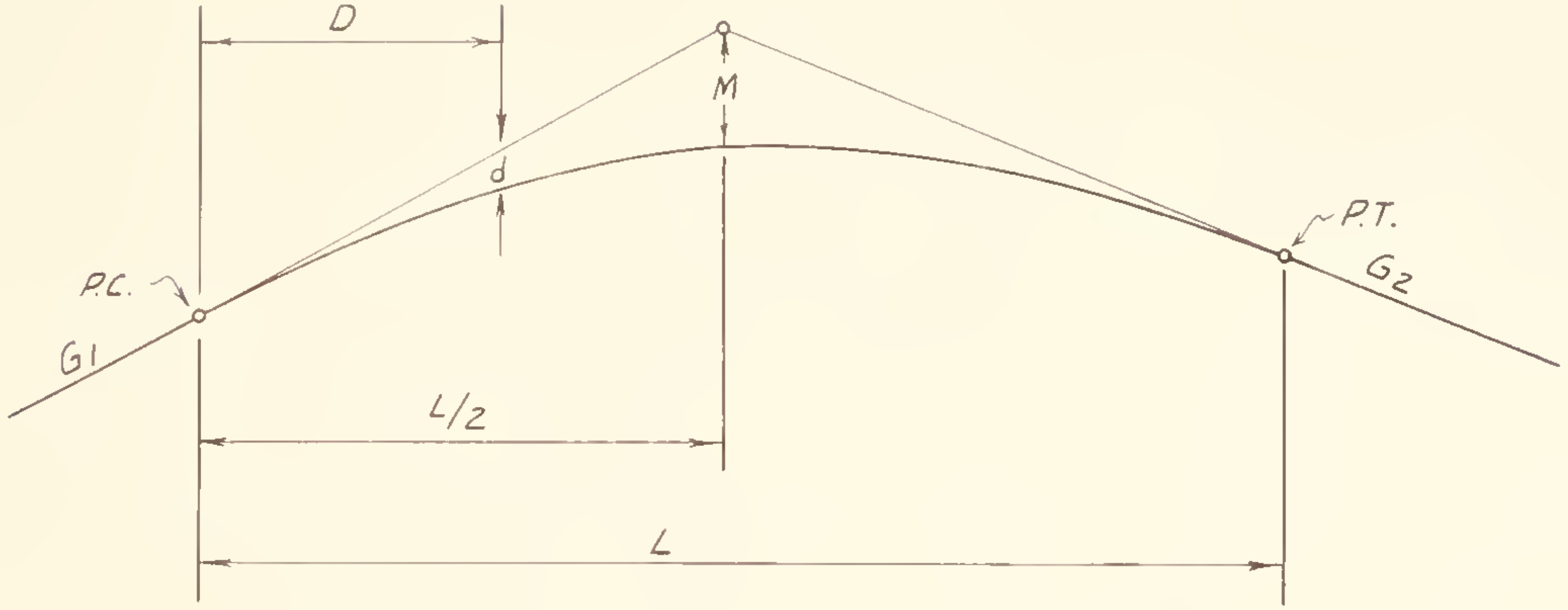
A tolerance of ±0.02 ft. in elevation is permitted when a computed grade is projected to a previously established P.I. elevation.

If necessary, additional decimal places will be used in grade computation to assure adherence to the P.I. elevation tolerance requirements.

Vertical Curve Elevations

The vertical curve is a parabolic arc. The offset distance from a parabola to its tangent varies as the square of the distance from its point of tangency. To determine profile grades on vertical curves, offsets from the tangent grades are computed and added to or subtracted from tangent grade elevations.

The sketch below illustrates vertical curve computations using the middle ordinate method.



$$MO = \frac{(G_1 - G_2)\,L}{8}$$

$$d = D^2 \frac{MO}{\left(\frac{L}{2}\right)^2}$$

MO	=	Middle ordinate (ft.)
G_1 and G_2	=	Gradients (expressed algebraically)
$G_1 - G_2$	=	Algebraic difference in gradients
L	=	Length of curve (stations)
$\frac{L}{2}$	=	1/2 the Length of curve (ft.)
d	=	Vertical curve correction (ft.)
D	=	Distance from P.C. or P.T. (ft.)
P.C.	=	Point of Curvature
P.T.	=	Point of Tangency

The formulae above can be used to determine vertical curve elevations on any parabolic vertical curve.

When computing vertical curve elevations on a slide rule, follow these steps:

1. Set the runner to MO on the A scale.
2. Bring $\frac{L}{2}$ on the C scale to the runner.
3. Set the runner to any desired value of D on the C scale.
4. Read d for that D value on the A scale.

Computation Procedures

Grades may be computed manually or by using the computer. Manual computation is facilitated by special columns for this purpose on standard sheets for earthwork computation. Elevations are recorded for each cross-section station, P.I.'s are identified by asterisks, vertical curve lengths are identified, and the profile grade elevations along vertical curves are shown. The figure below shows a portion of an earthwork computation sheet with grade computations properly recorded:

GRADES & V C.	V C CORR	CORR. ELEV. .... ELEV.	STATIONS
-0.46 %		79.93	1261 + 99
	0.00	79 47	1263
	+ 002	79.03 79.01	1264
	+ 0.14	78 69 78 55	1265
	+ 0 25	78 57 78.32	+50
	+ 0.30	78.52 78 22	+ 71
	+ 0 39	78.48 78 09	1266
	+ 0 51	78 43 77 92	+ 36
	+ 0.69	78.38 77.69	+ 85
+ 800' VC * MO = + 0.99	+ 0 99	78.39 77 40	1267 + 50
	+ 0.76	78.43 77.67	1268
	+ 0.53	78.51 77.98	+ 59
-0 53%	+ 0.39	78.59 78.20	1269
	+ 0 29	78.67 78.38	+ 35
	+ 0.14	78 87 78.73	1270
	+ 0 06	79.05 78.99	+50
	+ 0.02	79.28 79.26	1271
	0.00	79.52	+50
		79.86	1272 + 15

High or Low Points on Curves

High points on crest vertical curves and low points on sag vertical curves can be calculated as follows:

$$P = \frac{L\,G_1}{G_1 - G_2}$$

where P is the horizontal distance (in stations) from the P.C. to the high or low point on the curve.

CLIMBING LANES

During the design of vertical alignment, consideration should be given to the possible need for climbing lanes.

A climbing lane is an additional lane provided for slow moving vehicles on long, steep ascending grades. The design of climbing lanes is governed by several criteria such as design speed and length of grade. Refer to the "Highway Capacity Manual" for detailed design criteria. General criteria are presented below:

Lane Width

The widths of climbing lanes will be 12 feet.

Shoulder Width

Shoulders adjacent to climbing lanes will be at least four feet in width.

Transition

The transitions into and out of the climbing lanes should be on a 50:1 taper or at least 600 feet long.

Minimum Length

The minimum length for climbing lanes is 1,200 feet. If the design procedure indicates lengths below this limit, do not install a climbing lane.

Connecting Climbing Lanes

Two or more climbing lanes may occur on the same highway on the same long grade. If the distance from one climbing lane to the next is small, it is preferable to extend one climbing lane into the other to form one long climbing lane rather than leave a short stretch of 2-lane highway between them.

Climbing Lane Ends

The full climbing lane width is carried to a point beyond the crest of the hill where the truck has resumed a speed which is, at the most, only 15 m.p.h. less than the average speed and can return to the thru lane without hazard.

CROSS SECTIONS

Chapter Five

CROSS SECTIONS

GENERAL CONSIDERATIONS

Cross sections should provide graphical pictures of the relationships between proposed roadways and the existing ground surface.

Cross-section sheets can be prepared manually or with the computer. When using the computer, refer to the Computer Earthwork Design Manual.

This chapter presents guidelines for manual preparation of cross section sheets, including:

- Location-survey cross sections
- Roadway templates
- Earthwork
- Drainage
- Miscellaneous items

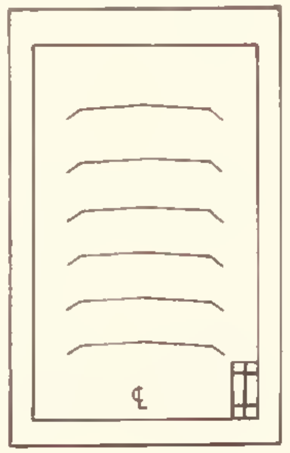
LOCATION-SURVEY CROSS SECTIONS

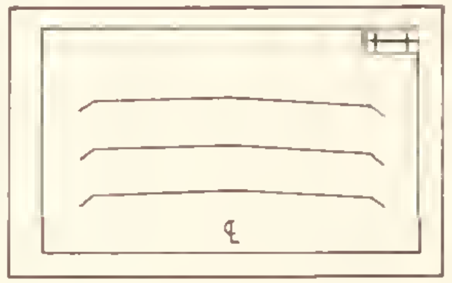
Survey Notes

The survey notes will provide the data needed to prepare location-survey cross sections. Guidelines for placing those data on cross-section sheets are presented in the following paragraphs.

Sheet Layout

Cross sections will be orientated vertically where the cross section limits fall within the margins of the sheets. Where wide cross sections would fall outside the margins, the cross sections will be orientated horizontally.



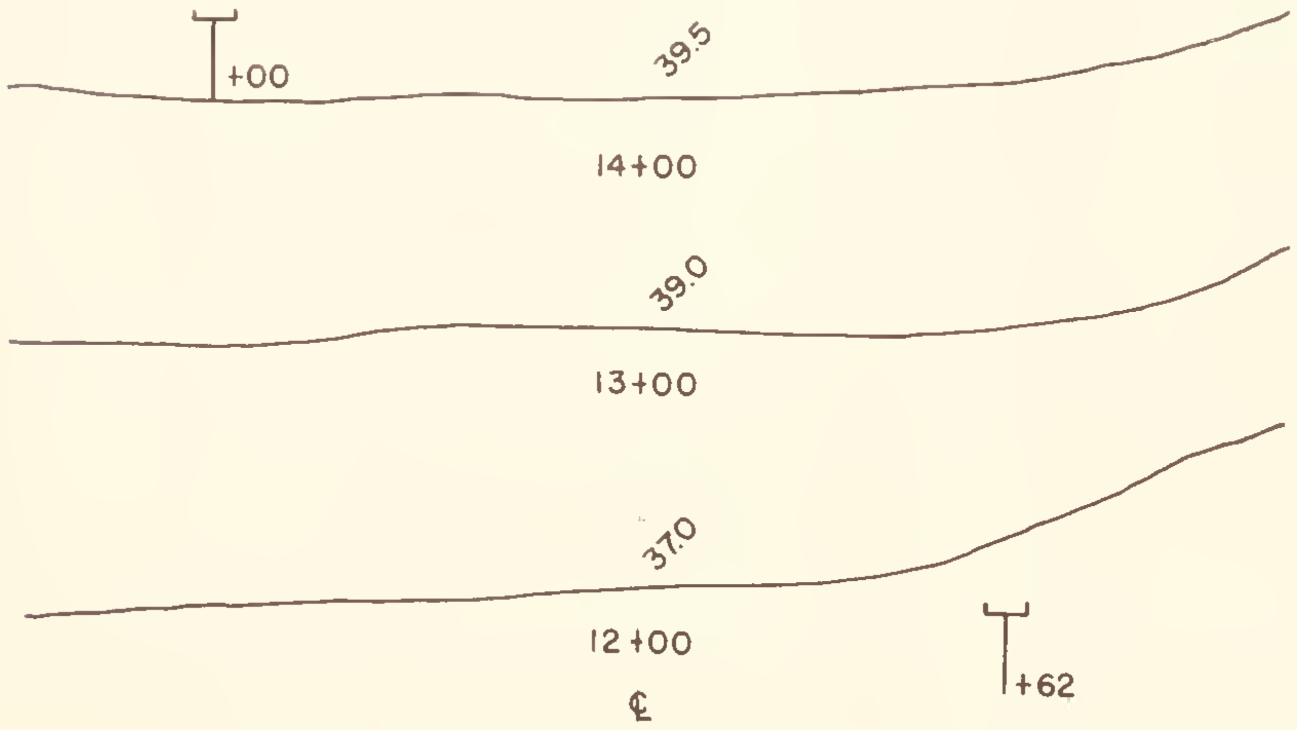


Spacing

The spaces between cross sections will be sufficient to avoid overlapping. Provision for sufficient spacing can be facilitated by checking the profile in anticipation of heavy cuts and fills.

Plotting

The initial plotting of present ground lines will be done in pencil. The plotted ground lines will be identified by station numbers and elevations at centerline as illustrated below:



PLOTTED GROUNDLINES
Showing Station Numbers and Ground Elevations at Centerline

The centerline symbol ℄ will be placed on centerline at the bottom of each cross section sheet, as shown in the illustration above.

Topography

Buildings, utilities and other major topography affected by construction operations will be depicted on cross section sheets. Initial drawings will be done in pencil.

Items of topography will be located using scaled distances for lateral locations and plus stations for longitudinal locations.

Sheet Numbers

As cross-section sheets are being developed, sequential sheet numbers, beginning with 1, will be written in pencil in the standard blocks provided in the upper right corners of the sheets.

Inking

After the location-survey cross sections have been pencil drawn and checked, the following items will be inked:

- Ground Lines
- Stationing
- Elevations of ground at centerline
- Major topography

No other items on cross section sheets will be inked.

ROADWAY TEMPLATES

After determining a typical roadway section and establishing a tentative profile grade, roadway templates will be plotted on the location-survey cross sections.

Roadway templates will be plotted in pencil. The plotted templates may have to be adjusted several times, so the pencil lead should be soft enough to permit thorough erasures.

Typical Sections

Standard typical sections are described with the illustrations accompanying the geometric design standards in Chapter One.

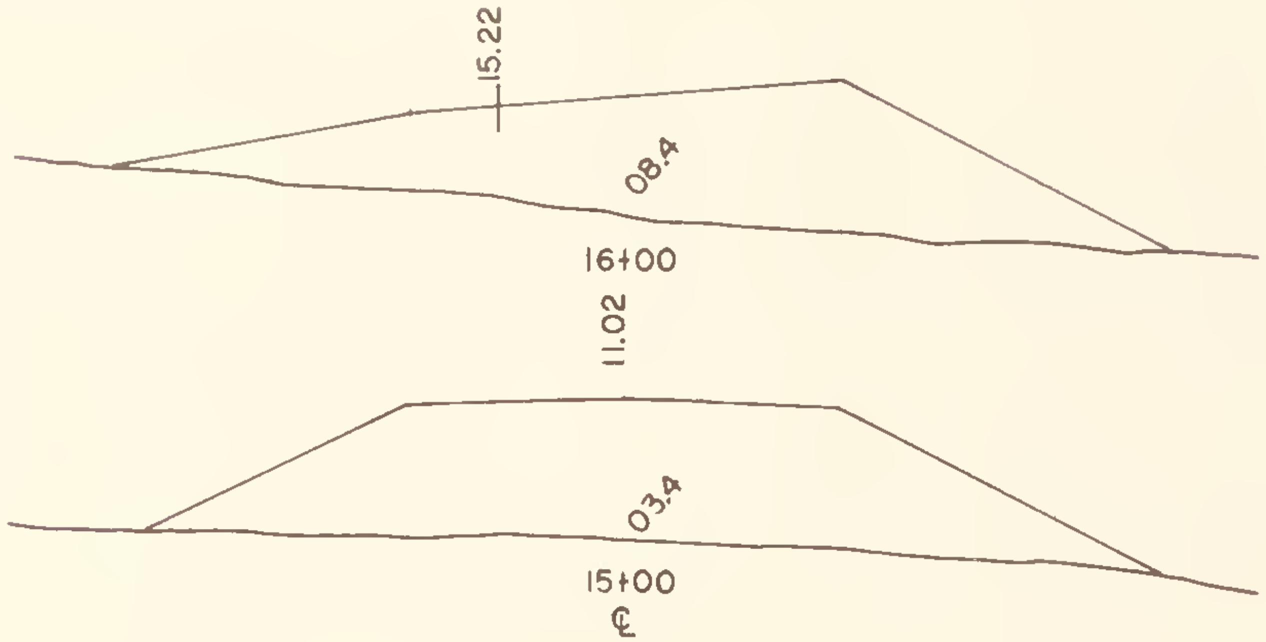
The Planning Report further defines specific elements of the typical section and sets forth modifications appropriate for individual projects.

Only the grading templates (subgrades and side slopes) will be plotted on the location-survey cross sections. Surfacing will not be shown. Unusual special excavation below the normal subgrade should be plotted.

Grade Elevations

Profile grade elevations, representing finished grade, should be taken directly from the earthwork computation sheets and entered on the cross section sheets.

Profile grade elevations should be orientated vertically above the profile grade points as shown in the example below:



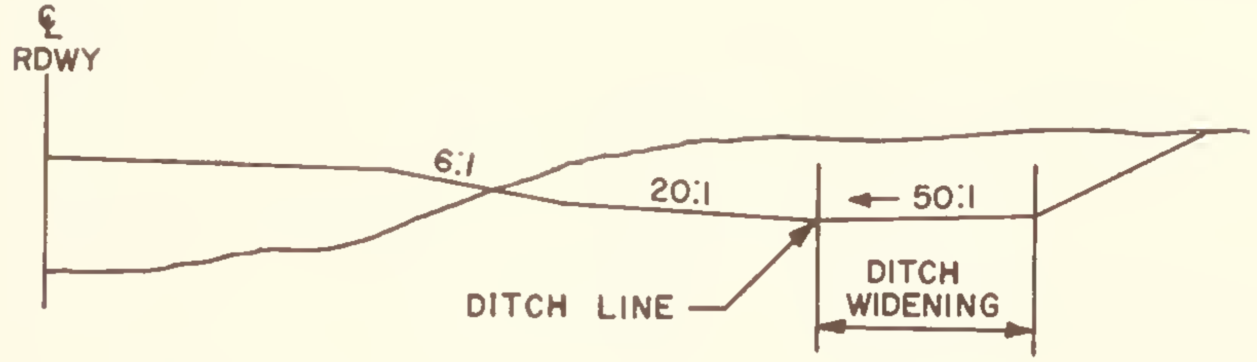
It should be remembered that profile grade points are shifted to points of rotation on superelevated curves and may represent gutter flowline or top of curb elevations on urban sections.

Slopes

The basic policies and criteria for slopes are presented in Chapter One. Cut slopes and fill slopes should be drawn in accordance with these criteria for existing conditions of fill height and cut depth.

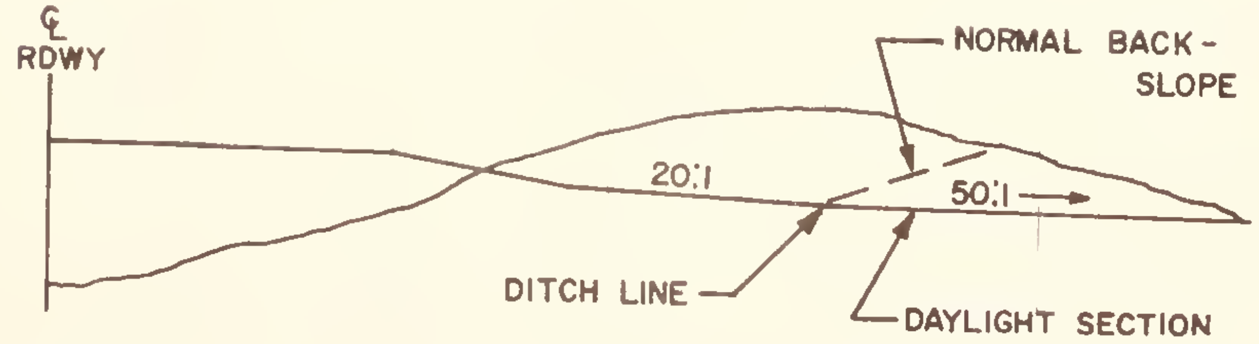
Ditch Widening

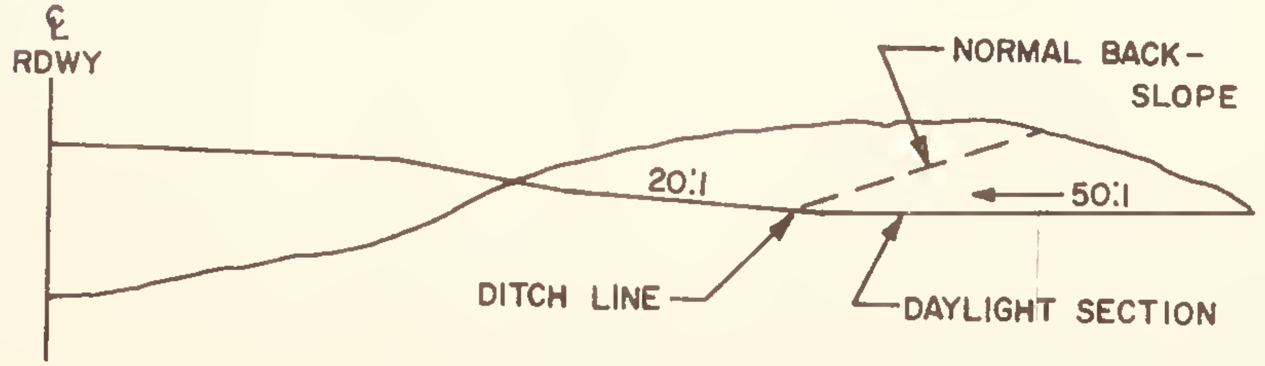
Where ditch widening is used to obtain additional excavation, begin the widening from the lowest point in the ditch and use a 50 : 1 slope to bring the drainage back to the normal ditch line. Ditch widening should be of uniform width throughout individual cuts.



Daylighting

Daylighting should be accomplished using a 50:1 slope either away from or toward the ditch line as shown below:





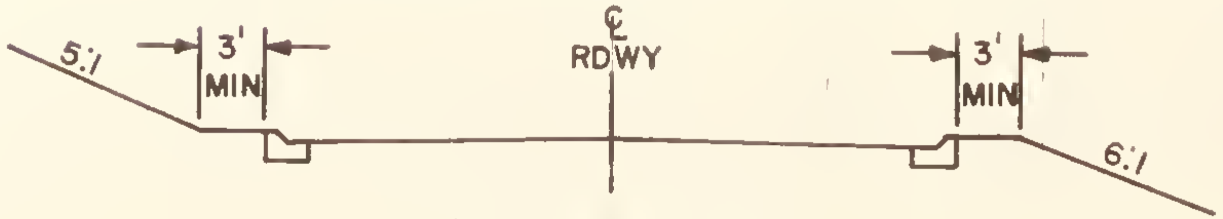
Daylighting may be used to provide needed fill material or convenient outfall points for roadside drainage. But, in no case should daylighting be used if guardrail must be provided as a result-- except for specifically designed turnout areas.

Slopes in Urban Areas

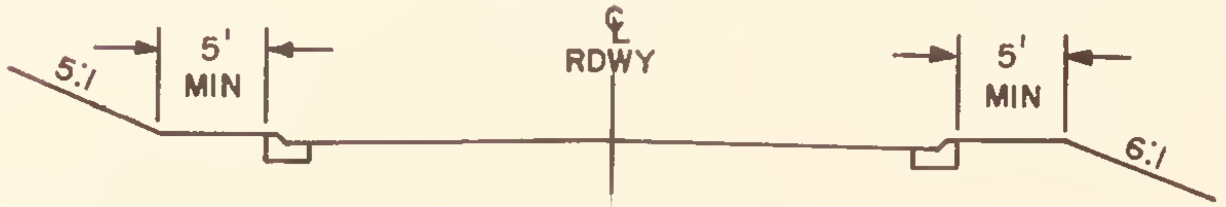
Gradelines in urban areas should be placed so that the top of the curb is level with the natural ground. It is desirable to leave the ground with a natural appearance.

Where the natural ground does not match the top of the curb, and a cut or a fill is required, follow these criteria:

- Provide a minimum 3-foot bench or berm behind the curb, level with the top of the curb and with no slope.
- Where a sidewalk is installed, widen the bench or berm to at least 5 feet, preferably 6 feet, before beginning the cut slope or the fill slope.
- Use a 6 : 1 cut slope or fill slope to meet the natural ground, except where a steeper slope is necessary to stay within the right-of-way limits.



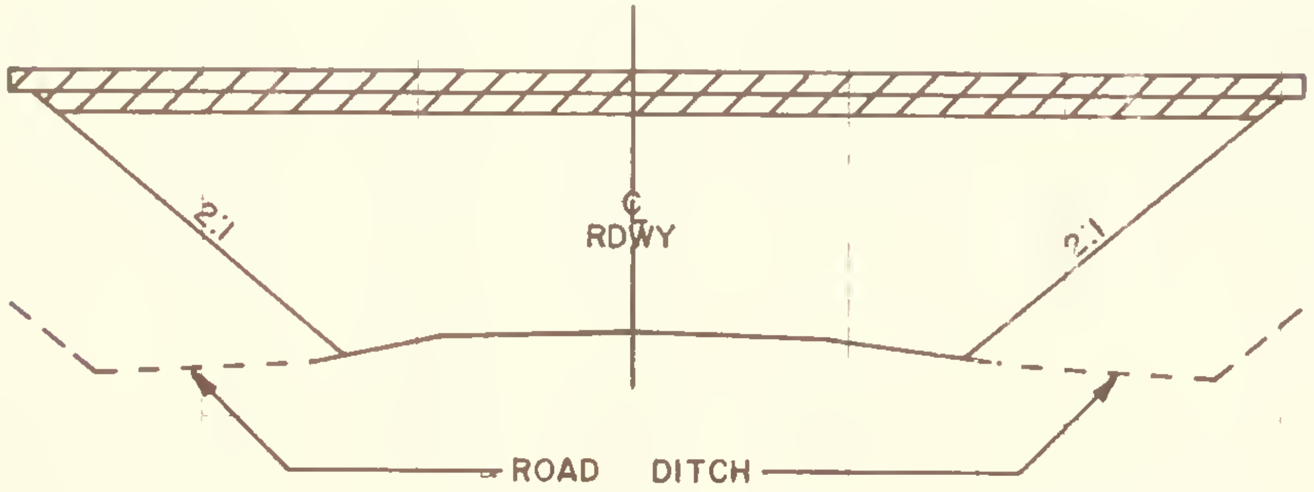
WITHOUT SIDEWALK



WITH SIDEWALK

Bridge End Slopes

At grade separations, the backslopes of roads under the bridge structures must be compatible with the bridge end slopes. Backslope transitions, if necessary, must be made to avoid cutting into bridge end slopes. The standard bridge end slope is 2 : 1.

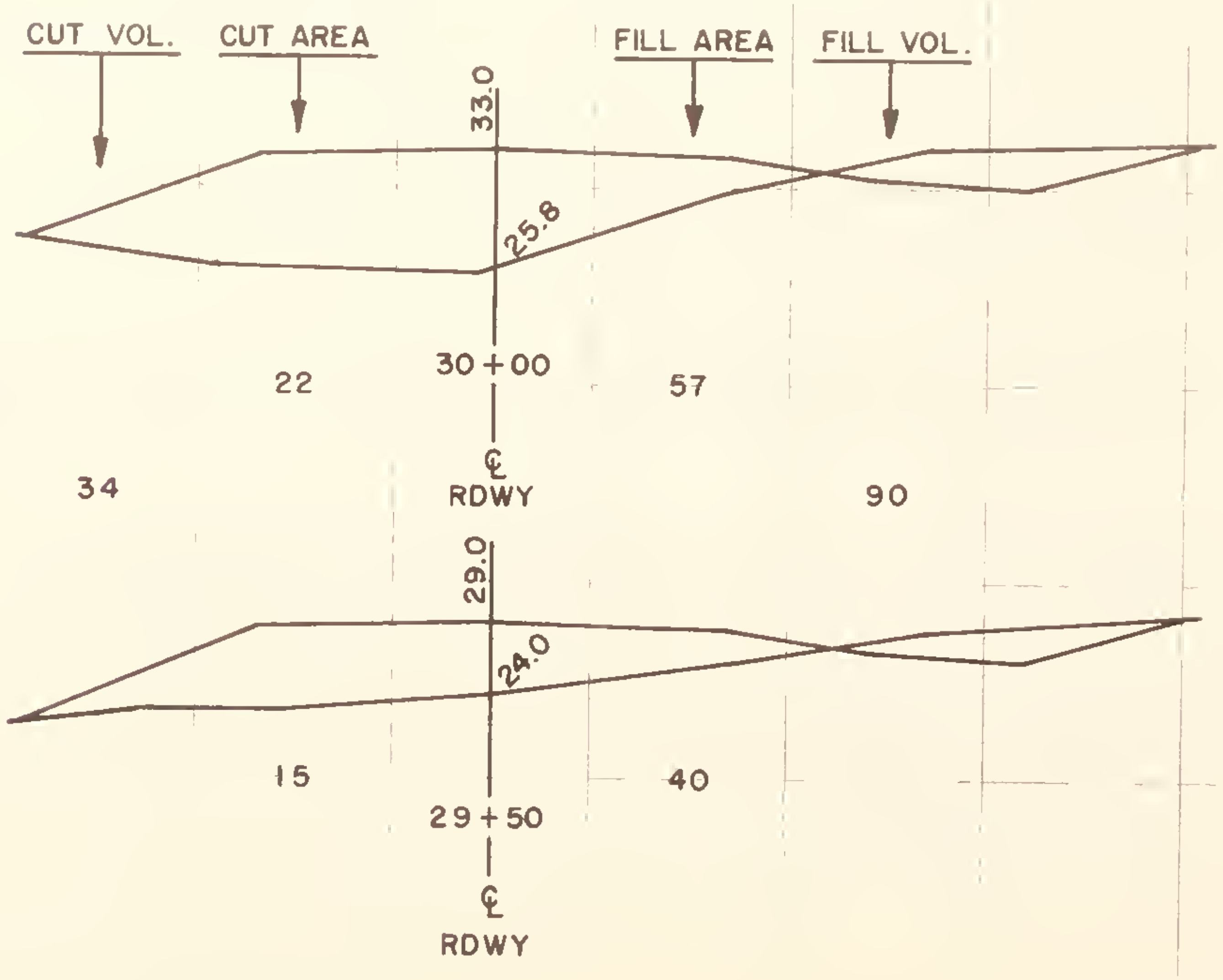


Before plotting roadway templates at grade separations, check the roadway typical sections with the bridge plans to see that they are compatible.

EARTHWORK

Procedures for computing earthwork are presented in Chapter Six. Guidelines for recording earthwork data on cross-section sheets are presented below.

Earthwork data to be recorded on cross-section sheets are (1) the areas of cut and fill, expressed in square feet, at each cross section and (2) the volumes of cut and unadjusted fill, expressed in cubic yards, between adjacent cross sections. This data will be recorded in pencil, with cut quantities on the left and fill quantities on the right as shown below. The column headings should be identified at the top of each sheet with an imprint of a standard rubber stamp provided for this purpose.



DRAINAGE

The basic policies and criteria for drainage are presented in Chapter Seven. Guidelines for showing drainage items on cross sections are presented below.

Drainage items will be shown in pencil. Drainage details may have to be modified several times, so the pencil lead should be soft enough to permit erasures.

Culverts

Culverts must be fully described on cross-section sheets. Each description will include a drawing and a note or "call out". The forms of the drawings and the contents of the notes are discussed below and illustrated on the next page.

Mainline Culverts Without Skews

Mainline culverts without skews will be drawn on the closest adjacent cross section of the mainline. Each culvert drawing will show lines representing the top of the pipe, the flowline of the pipe and, where applicable, flared end terminal sections.

Mainline Culverts With Skews

Skewed mainline culverts will be drawn on the closest adjacent cross sections of the mainline. Each drawing will show lines representing the top of the pipe, the flowline of the pipe and, where applicable, flared end terminal sections.

In addition, the true angle of skew will be drawn so that the pipe lengths can be scaled from the cross-section sheets. The culverts should be represented with single lines showing the station locations of the inlets and the outlets, the true skew angles, and the true lengths of the culverts, including flared end terminal sections.

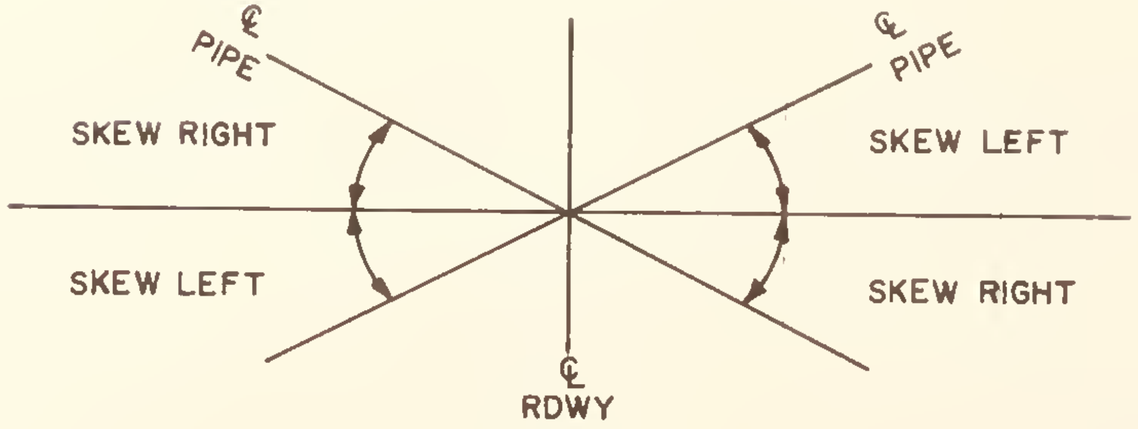
Approach Pipes and Median Drains

Approach pipes and median drains will be shown as circles on the closest adjacent mainline cross sections.

Notes

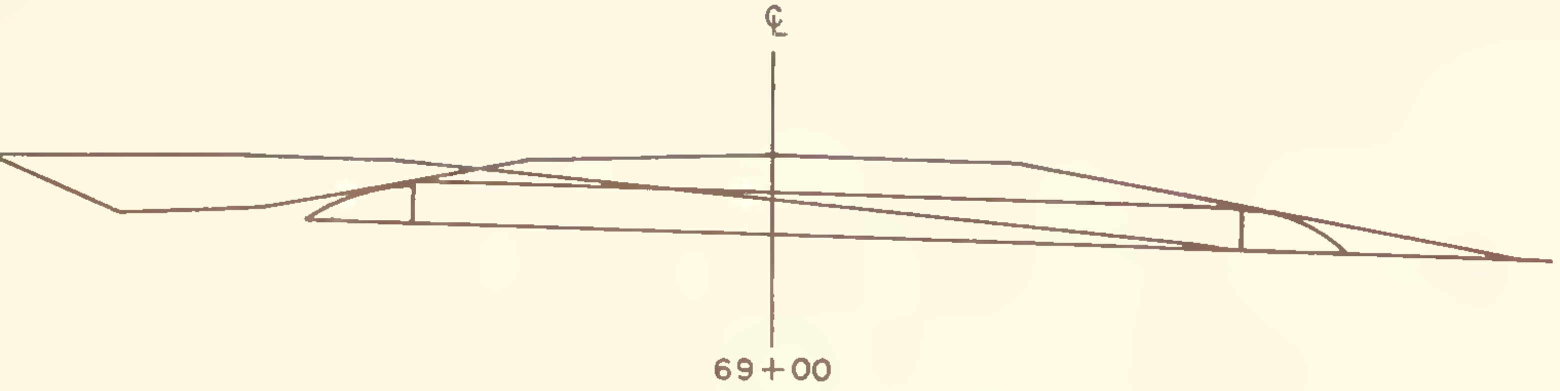
Culvert drawings will be supplemented with notes containing the following data, as appropriate:

- Station location of culvert at mainline centerline
- Description of pipe, including inside diameter or rise and span, length, type and gauge or thickness
- Amount of skew in degrees, measured right or left as shown below:



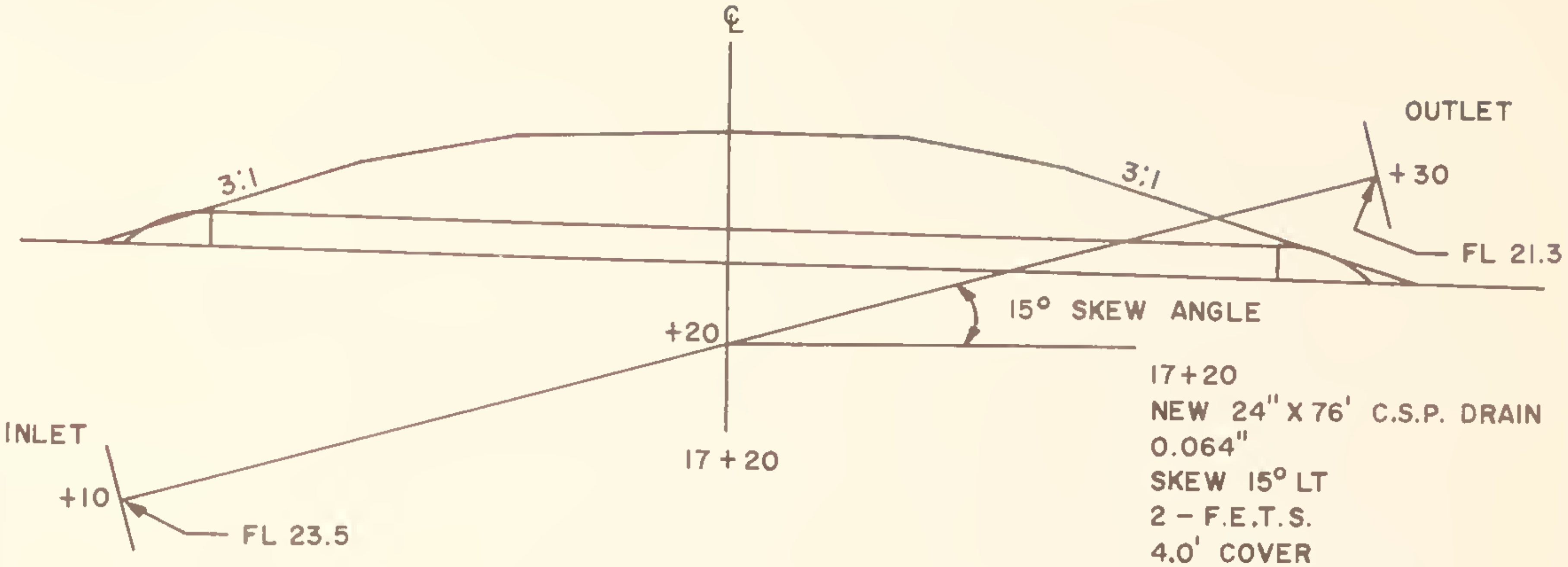
- Description of end treatment
- Height of cover, measured from the top of the pipe to the top of the finished surface
- Cubic yards of culvert excavation
- Quantity of bedding material

STANDARD CROSS - SECTION DESCRIPTIONS OF CULVERTS



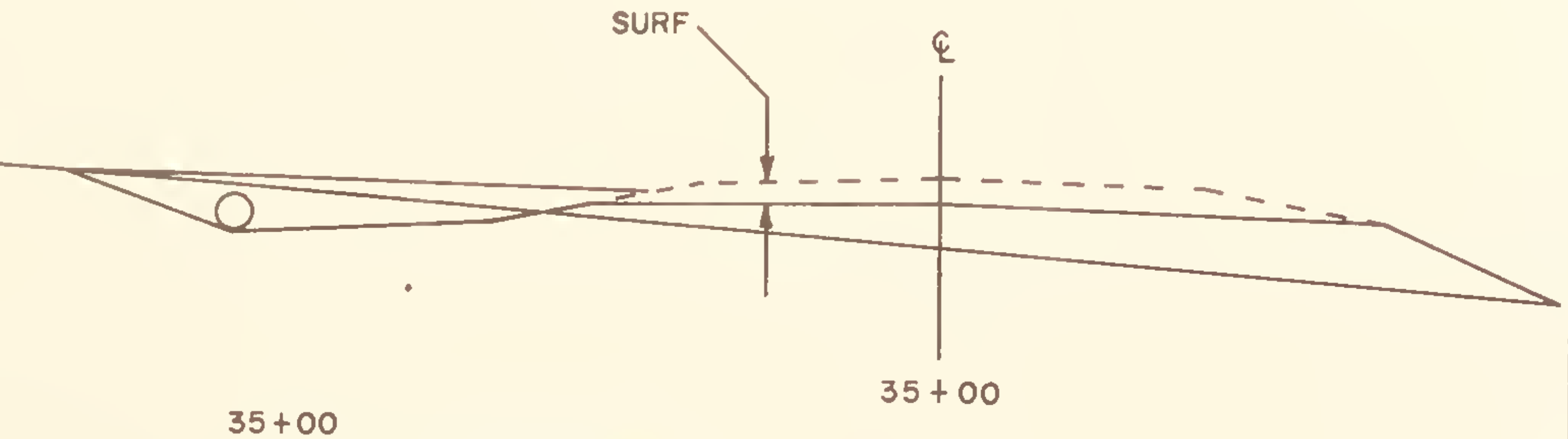
69 + 00
NEW 24" X 60' C.S.P. DRAIN
0.064"
2- F.E.T.S.
4.5' COVER
25 C.Y. CULV. EXC.

MAINLINE CULVERT WITHOUT SKEW



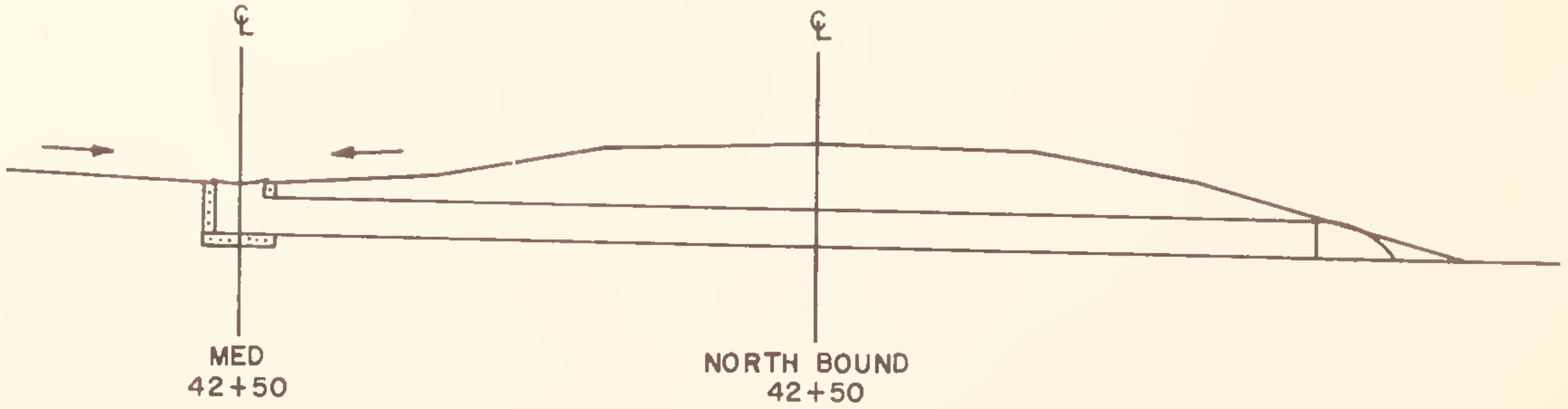
17+20
NEW 24" X 76' C.S.P. DRAIN
0.064"
SKEW 15° LT
2 - F.E.T.S.
4.0' COVER
15.0 C.Y. CULV. EXC.

MAINLINE CULVERT WITH SKEW



35+00
NEW 24" X 56' PIPE DRAIN
(ALTERNATE BID)
2 - F.E.T.S.
1.5' COVER
5.0 C.Y. CULV. EXC.

APPROACH PIPE



42+50 (NORTHBOUND)
NEW 24" X 68' C.S.P. DRAIN
0.064"
1 - F.E.T.S. RT
1 - NEW MEDIAN INLET COVER
TYPE 2
3.0' COVER
20.0 C.Y. CULV. EXC.

MEDIAN DRAIN

Drop Inlets and Storm Sewers

Drop inlets and storm sewers will be shown on the closest adjacent mainline cross sections. Draw drop inlets to the top-of-wall elevations and show the flowlines and the tops of pipes. Where storm sewers run parallel to the mainline, their locations and flowlines will be shown on each mainline cross section.

Drop inlets and storm sewers also will be described by notation. Each note should indicate the station location, full descriptions of the items required and the cubic yards of culvert excavation. A typical note is shown below:

1736 + 94
NEW 12" x 30' R.C.P. (CL. 2)
1 NEW DROP INLET LT.
15 C.Y. CULV. EXC.
CONN. TO NEW M.H.

Drain Ditches

Inlet and outlet drain ditches will be drawn on cross sections, and will be described by notation wherever they are used. Each note should indicate the station location, the cubic yards of additional excavation, whether it is an inlet ditch or an outlet ditch and whether it is left or right of the mainline. A typical note is shown below:

173 + 50
25 C.Y. ADD. EXC.
OUTLET DT. LT.

Irrigation

All irrigation items will be drawn on the closest adjacent mainline cross sections. The drawings will be supplemented by notes fully describing the items and specifically indicating that they are irrigation items. A typical note is shown below:

71 + 75
NEW 24" x 140' C.S.P. IRR. SYPHON, 0.064"
SKEW 20° RT.
4.5' COVER
110 C.Y. CULV. EXC.
NEW INLET AND OUTLET HDWL.'s
S = 5.5' S' = 5.1'
1.84 C.Y. CL. DD CONC.

SSPPC Installations

A typical note for large culverts should be in the format shown below:

1250 + 00
NEW 180" x 120' SSPPC
0.109"
COVER = 10.0'
SKEW = 30° LT.
ENDS SKEW STEP BEVELED 2 : 1
145 C.Y. BEDDING MATERIAL
175 C.Y. CULVERT EXC.
6.0 C.Y. CLASS DD CONC. (cutoff walls)
4.5 C.Y. CLASS DD CONC. (inlet edge protection)
31.4 C.Y. TYPE B RANDOM RIPRAP (outlet)

Curb and Gutter Sections

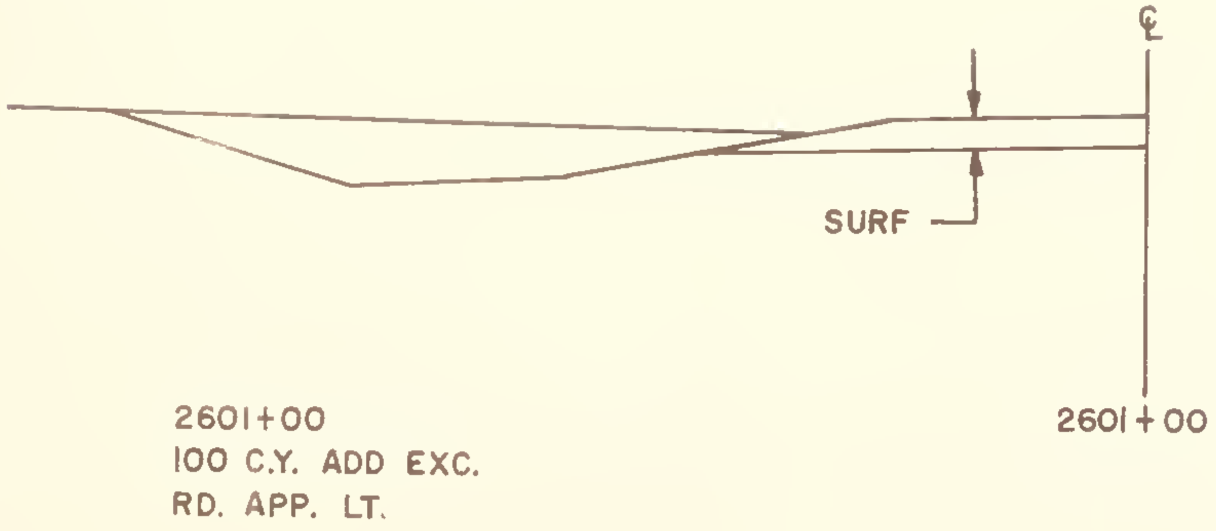
Curbs and gutters will be drawn on cross sections only where they adjoin drop inlets.

MISCELLANEOUS

Several types of miscellaneous items will be shown on cross-section sheets. Guidelines for showing some of the most common items are presented below.

Road Approaches

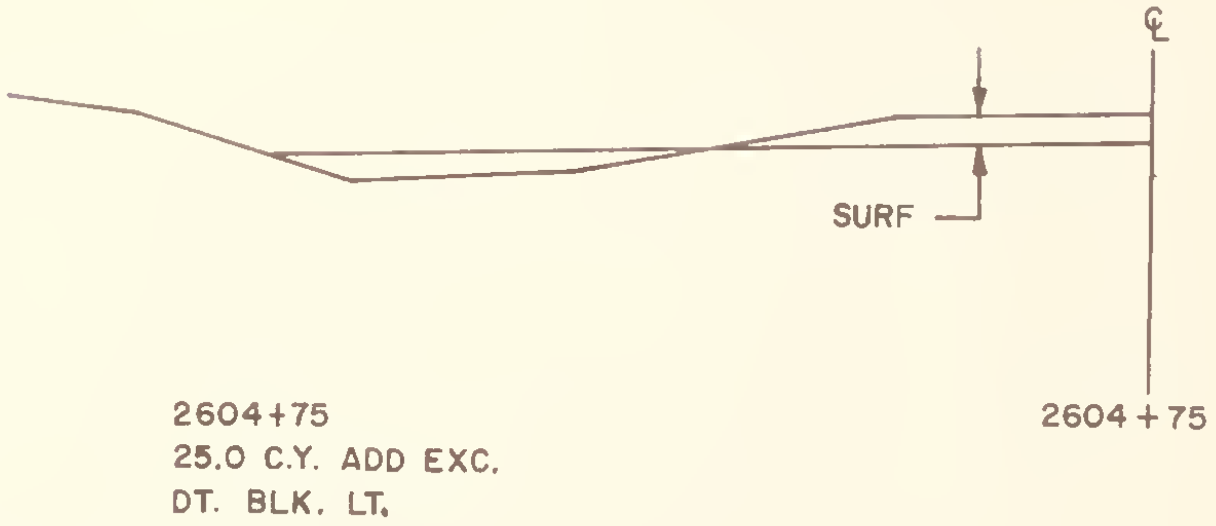
Road approaches will be drawn on the closest adjacent cross sections of the mainline and noted in the manner shown below:



Individual cross sections of road approaches will not be shown except in cases of unusual special design.

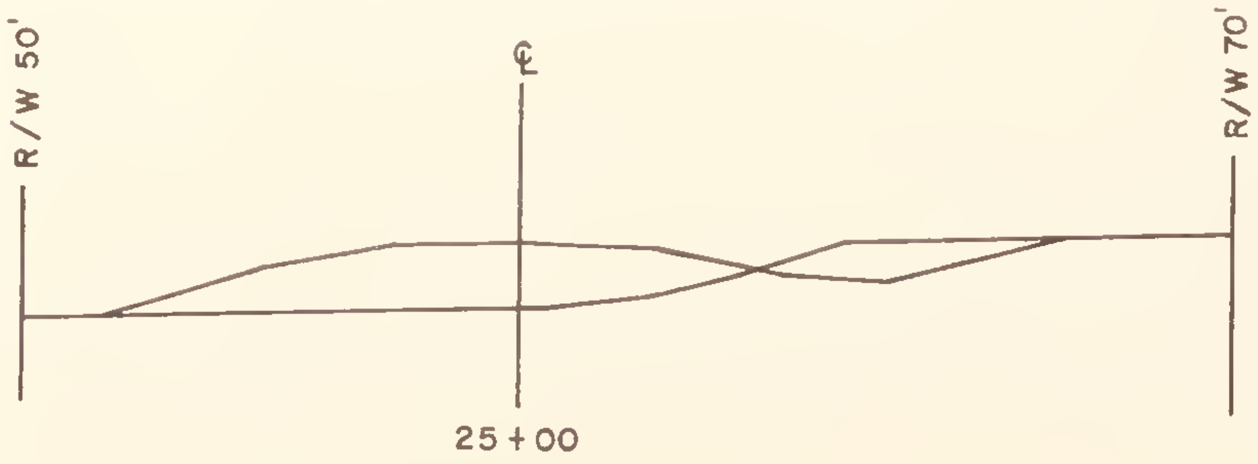
Ditch Blocks

Ditch blocks will be drawn on the closest adjacent cross sections of the mainline and noted in the manner shown below:



Right-of-Way Limits

Right-of-way limits will be shown on each cross section with lines indicating the distances from centerline. See the example below:



EARTHWORK COMPUTATIONS

Chapter Six

EARTHWORK COMPUTATIONS

GENERAL CONSIDERATIONS

Earthwork computations may be made manually or with the computer. When using the computer, refer to the "Computer Earthwork Design Manual." When using the manual method, use the guideline presented in this chapter.

Earthwork computations involve these basic steps:

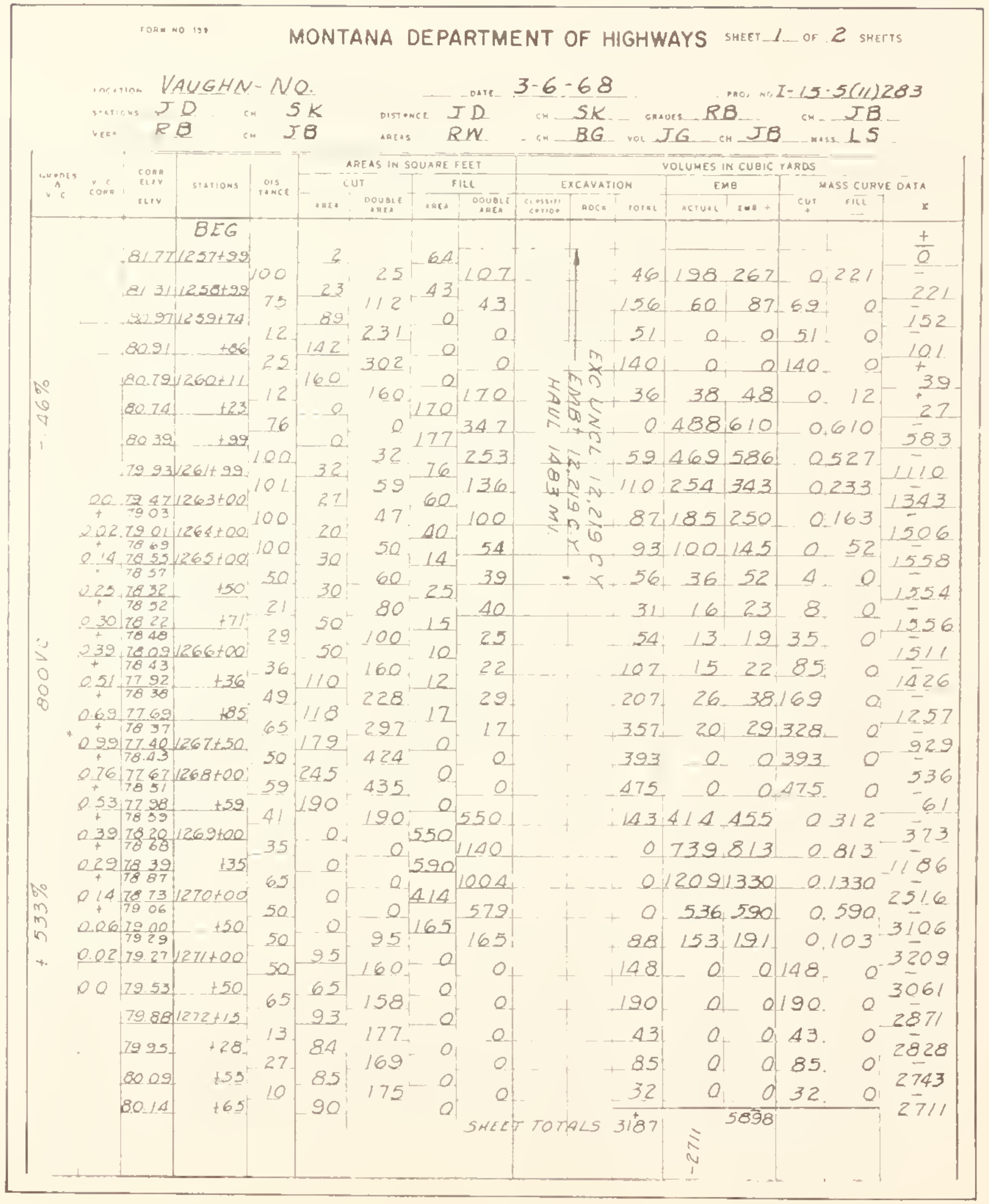
- Computing cross-section end areas of cut and fill
- Computing volumes of excavation and embankment
- Plotting mass diagrams and computing haul

COMPUTATION SHEETS

Earthwork computations should be recorded on the computation sheets provided by the Department. A sample computation sheet, properly completed, is shown at the right.

The first five columns of the sheet (grades, vertical curve data, grade elevations, stations and distance between stations) will be completed during the process of computing grades. The remaining columns will be used for documenting cross-section areas, volumes between cross sections and mass curve data to be used for plotting mass diagrams.

Computation sheets should be prepared in sets of 30 stations. This will facilitate the preparation of mass diagrams as explained later.



FORM NO 139

MONTANA DEPARTMENT OF HIGHWAYS SHEET 1 OF 2 SHEETS

LOCATION VAUGHN-NO. DATE 3-6-68 PROJ. NO. I-15-5(11)283
STATIONS JD CH 5K DISTANCE JD CH SK GRADES RB CH JB
VERT RB CH JB AREAS RW CH BG VOL JG CH JB MASS LS

GRADES A V C	V C CORR	CORR ELEV / ELEV	STATIONS	DISTANCE	AREAS IN SQUARE FEET: CUT AREA	CUT DOUBLE AREA	FILL AREA	FILL DOUBLE AREA	VOLUMES IN CUBIC YARDS: EXCAVATION CLASSIFICATION	ROCK	TOTAL	EMB ACTUAL	EMB +	MASS CURVE DATA: CUT +	FILL −	Σ
			BEG													
		81.77	1257+99		2		64									+0
				100		25		107			46	198	267	0	221	
		81 31	1258+99		23		43									−221
				75		112		43			156	60	87	69	0	
		81 97	1259+74		89		0									−152
				12		231		0			51	0	0	51	0	
		80.91	+86		142		0									−101
				25		302		0			140	0	0	140	0	
−.46%		80.79	1260+11		160		0									+39
				12		160		170			36	38	48	0	12	
		80.74	+23		0		170									+27
				76		0		347			0	488	610	0	610	
		80 39	+99		0		177									−583
				100		32		253			59	469	586	0	527	
		79 93	1261+99		32		76									−1110
				101		59		136			110	254	343	0	233	
	00	79 47	1263+00		27		60									−1343
				100		47		100			87	185	250	0	163	
	+ 0.02	79 03 79 01	1264+00		20		40									−1506
				100		50		54			93	100	145	0	52	
	+ 0.14	78 69 78 55	1265+00		30		14									−1558
				50		60		39			56	36	52	4	0	
	+ 0.25	78 57 78 32	+50		30		25									−1554
				21		80		40			31	16	23	8	0	
	+ 0.30	78 52 78 22	+71		50		15									−1556
				29		100		25			54	13	19	35	0	
	+ 0.39	78 48 78 09	1266+00		50		10									−1511
				36		160		22			107	15	22	85	0	
800 VC	+ 0.51	78 43 77 92	+36		110		12									−1426
				49		228		29			207	26	38	169	0	
	+ 0.69	78 38 77 69	+85		118		17									−1257
				65		297		17			357	20	29	328	0	
	+ 0.99	78 37 77 40	1267+50		179		0									−929
				50		424		0			393	0	0	393	0	
	+ 0.76	78.43 77 67	1268+00		245		0									−536
				59		435		0			475	0	0	475	0	
	+ 0.53	78 51 77 98	+59		190		0									−61
				41		190		550			143	414	455	0	312	
	+ 0.39	78 59 78 20	1269+00		0		550									−373
				35		0		1140			0	739	813	0	813	
	+ 0.29	78 68 78 39	+35		0		590									−1186
				65		0		1004			0	1209	1330	0	1330	
+ .533%	+ 0.14	78 87 78 73	1270+00		0		414									−2516
				50		0		579			0	536	590	0	590	
	+ 0.06	79 06 79 00	+50		0		165									−3106
				50		95		165			88	153	191	0	103	
	0.02	79 29 79 27	1271+00		95		0									−3209
				50		160		0			148	0	0	148	0	
	0 0	79 53	+50		65		0									−3061
				65		158		0			190	0	0	190	0	
		79 88	1272+15		93		0									−2871
				13		177		0			43	0	0	43	0	
		79 95	+28		84		0									−2828
				27		169		0			85	0	0	85	0	
		80 09	+55		85		0									−2743
				10		175		0			32	0	0	32	0	
		80.14	+65		90		0									−2711
								SHEET TOTALS			+3187		−5898			

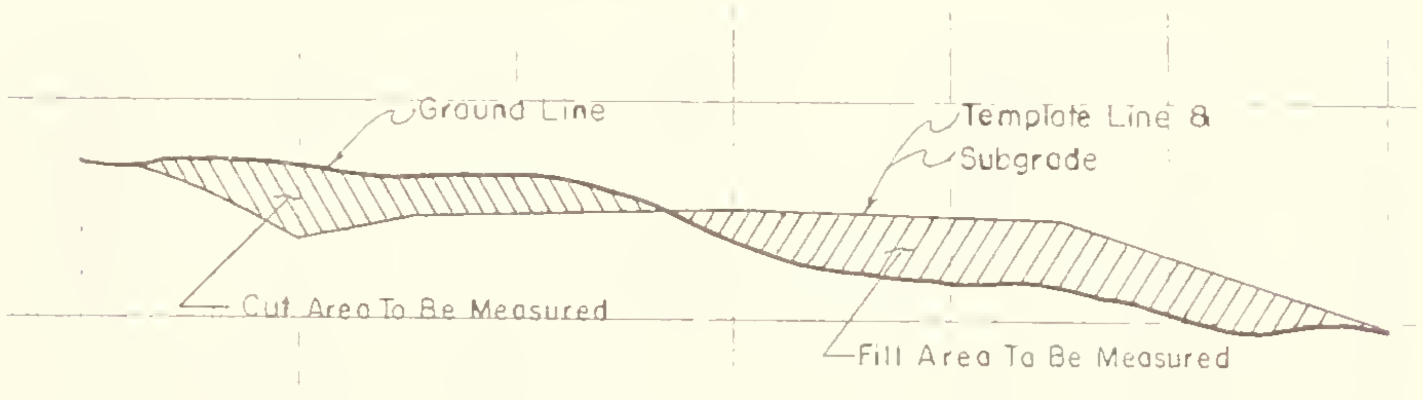
HAUL 1483 MV
EMB+ 12,219 C.Y.
EXC UNCL 12,219 C.Y.

−2711

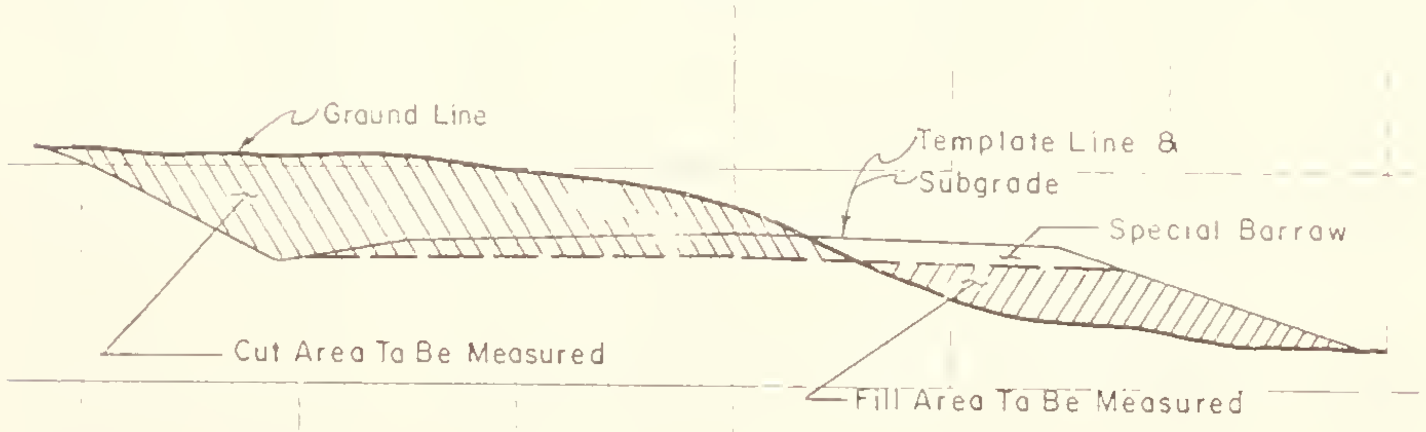
COMPUTING CROSS-SECTION END AREAS

Definition of Areas

The end areas to be computed are defined by the ground lines and the template lines, except in fill areas where special borrow is used. Where special borrow is used, fill areas will be computed to the bottom of the special borrow. See the example below:



SECTION WITHOUT SPECIAL BORROW



SECTION WITH SPECIAL BORROW

Computation Method

The end areas, in square feet, will be measured with planimeters. Where the cross-section scale is 1" = 10' vertically and horizontally, planimeter readings will show the true areas. For other scales, planimeter readings must be adjusted accordingly to obtain true areas. For example, if the scale is 1" = 5' vertically and horizontally, divide the planimeter reading by 4 to obtain the true area.

The end areas of cut and fill will be recorded below each cross section as described in Chapter Five.

COMPUTING VOLUMES

Computation Formula

Volumes of excavation and embankment will be computed using the average-end-area formula expressed below:

$$V = \frac{A_1 + A_2}{2} \times D \div 27$$

where:

V = Volume, in cubic yards

$A_1 + A_2$ = Sum of cut or fill end areas of adjacent sections, in square feet

D = Distance between sections, in feet

27 = Conversion factor (27 cu. ft. per cu. yd.)

To facilitate computation, this formula can be shortened to:

$$V = (A_1 + A_2)\ K$$

where:

$$K = \frac{D}{2 \times 27} \quad \text{or} \quad \frac{D}{54}$$

The table below shows the K value for each one-foot interval of distance up to 100 feet. Volumes between cross sections can be computed by multiplying the sum of the adjacent end areas by the K value for the distance between the cross sections.

Dist. in ft.	K Factor	Dist. in ft.	K Factor	Dist. in ft.	K Factor	Dist. in ft.	K Factor	Dist. in ft.	K Factor
1	.01852	21	.38889	41	.75926	61	1.12963	81	1.50000
2	.03704	22	.40741	42	.77778	62	1.14815	82	1.51852
3	.05556	23	.42593	43	.79630	63	1.16667	83	1.53704
4	.07407	24	.44444	44	.81481	64	1.18519	84	1.55556
5	.09259	25	.46296	45	.83333	65	1.20370	85	1.57407
6	.11111	26	.48148	46	.85185	66	1.22222	86	1.59259
7	.12963	27	.50000	47	.87037	67	1.24074	87	1.61111
8	.14815	28	.51852	48	.88889	68	1.25926	88	1.62963
9	.16667	29	.53704	49	.90741	69	1.27778	89	1.64815
10	.18519	30	.55556	50	.92593	70	1.29630	90	1.66667
11	.20370	31	.57407	51	.94444	71	1.31481	91	1.68519
12	.22222	32	.59259	52	.96296	72	1.33333	92	1.70370
13	.24074	33	.61111	53	.98148	73	1.35185	93	1.72222
14	.25926	34	.62963	54	1.00000	74	1.37037	94	1.74074
15	.27778	35	.64815	55	1.01852	75	1.38889	95	1.75926
16	.29630	36	.66667	56	1.03704	76	1.40741	96	1.77778
17	.31481	37	.68519	57	1.05556	77	1.42593	97	1.79630
18	.33333	38	.70370	58	1.07407	78	1.44444	98	1.81481
19	.35185	39	.72222	59	1.09259	79	1.46296	99	1.83333
20	.37037	40	.7404	60	1.11111	80	1.48148	100	1.85185

The cut and fill areas for each cross section should be transferred from the cross-section sheet to the computation sheet and recorded in the "Area" column. The "Double Area" column shows the sum of the adjacent cross-section areas. The product of the "Double Area" and the appropriate K value for the distance gives the volume in cubic yards between the cross sections. The volumes should be recorded in the "Total" column for excavation and in the "Actual" column for embankment. If instructions have been given to classify certain areas as rock excavation, the cut volume should be recorded in the "Rock" column.

The volumes of excavation and embankment will be transferred from the "Total" and "Actual" columns and recorded between cross sections as discussed in Chapter Five.

Shrinkage and Swell Factors

The volumes of embankment recorded in the "Actual" column will be adjusted for shrinkage and swell. The adjusted volumes will be recorded in the "Emb. +" column.

Volumes will be adjusted for shrinkage and swell as recommended by the District Engineer. In the absence of recommendations from the District Engineer, use the standard tables as presented below.

The Standard Shrinkage Table shows a "Shrinkage Factor" for each of several ranges of "Double Areas." To obtain the "Emb. +" volume, multiply the "Actual" embankment by the shrinkage factor appropriate for the double area.

STANDARD SHRINKAGE TABLE

Double Area	Shrinkage Factor
0 - 54	1.45
55 - 162	1.35
163 - 378	1.25
379 - 540	1.15
Over 540	1.10

The Standard Swell Table is to be used when rock quantities are involved. To obtain the "Emb.+" volume, multiply the "Actual" embankment by the swell factor appropriate for estimated percentage of rock.

STANDARD SWELL TABLE

Estimated Percent Rock	Swell Factor
0 - 10	1.00
11 - 25	0.95
26 - 50	0.90
51 - 75	0.80
76 - 90	0.75
91 - 100	0.70

Mass Curve Data

Mass Curve data will be computed and recorded in the last three columns of the computation sheet.

Where the excavation quantity exceeds the embankment quantity between two cross sections, the difference is recorded in the cut (+) column. When the embankment exceeds the excavation, the difference is recorded in the fill (-) column.

In the last column, record the accumulated difference between cut and fill at each cross section. An accumulated surplus of excavation is identified with the plus symbol: + . Where there is insufficient accumulated excavation for the required fill, the mass curve value is identified with the minus symbol: - .

As discussed earlier, computation sheets should be prepared in sets of 30 stations. At the beginning of each set, record the mass in the last column as 0 (zero) and compute the mass accordingly. This will make it easier to prepare mass diagrams as discussed in the next section.

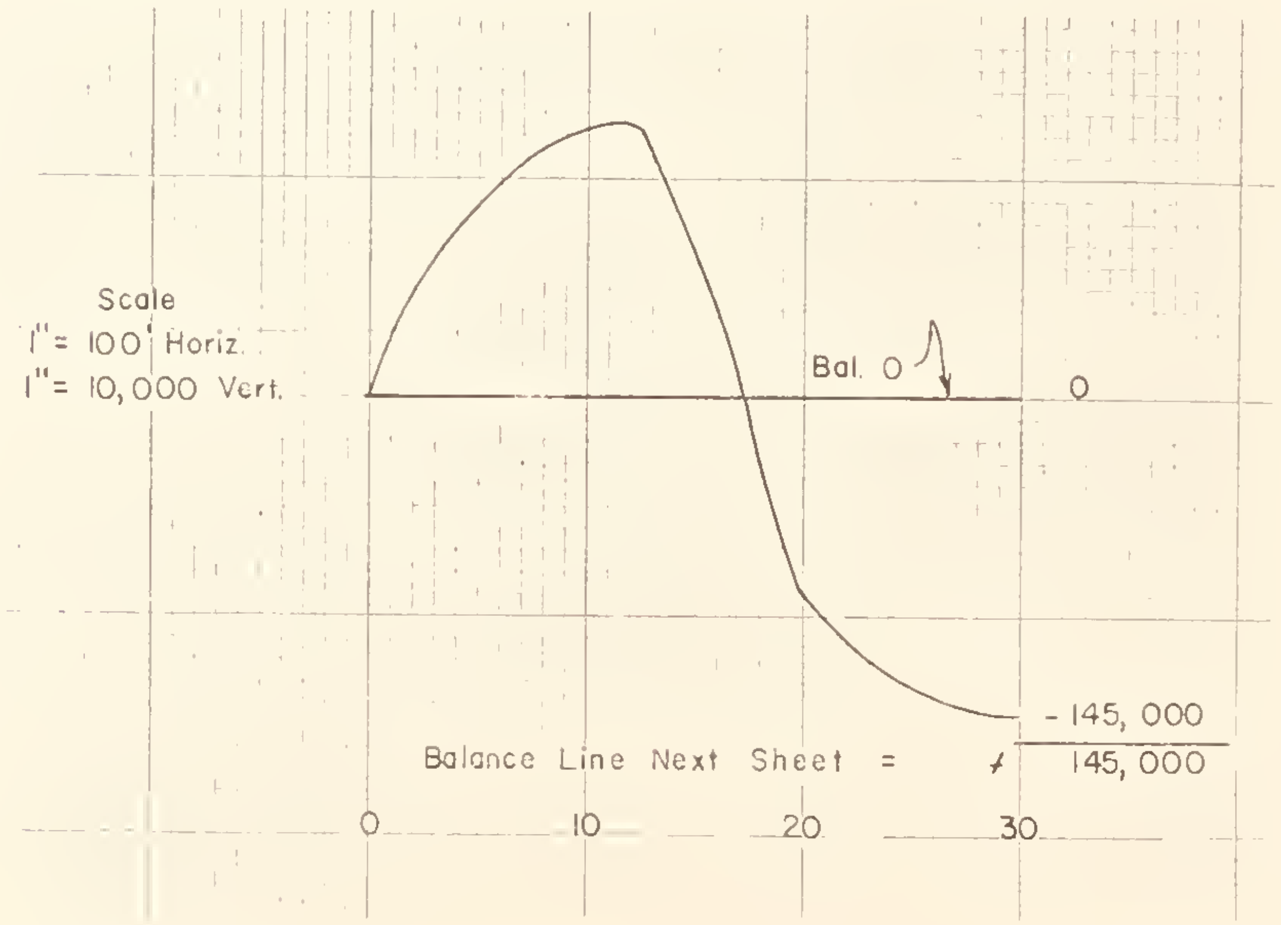
COMPUTING HAUL

Haul will be computed for all projects. The steps involved in computing haul are:

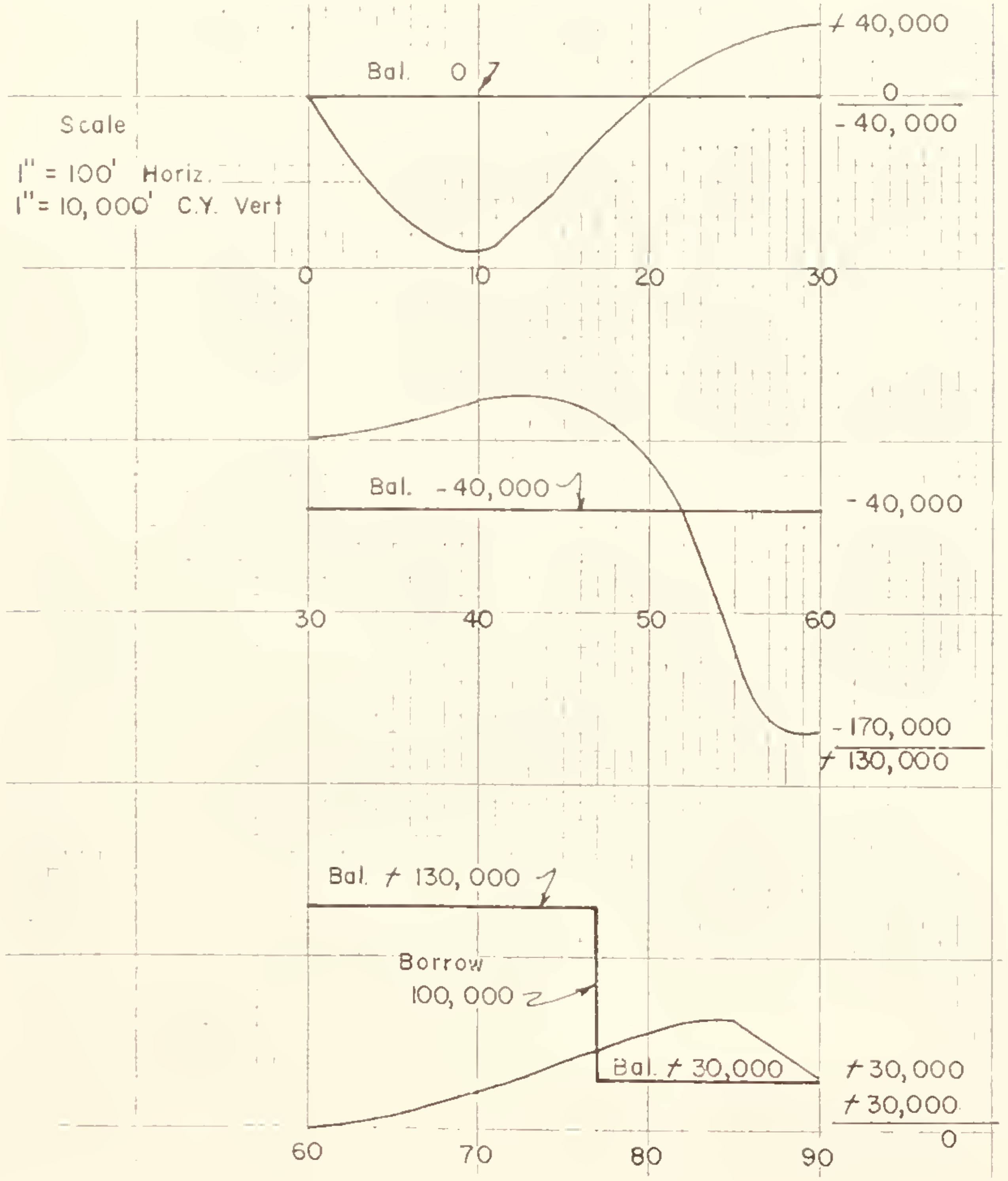
- Plotting the mass
- Computing splits
- Computing haul between splits

Plotting the Working Mass Diagram

Using cross section paper, plot the accumulative mass at each station as shown in the last column of the computation sheet. The horizontal scale should be 1 station per inch. A vertical scale should be selected which adequately illustrates the changes in accumulative mass -- normally a scale between about 2000 to 20,000 cubic yards per inch. If space permits, several 30-station sets of mass may be plotted on one sheet. An example mass diagram is shown below.



If a review of the mass diagram indicates that more balanced earthwork is necessary, grade adjustments may be made at this time. Any grade adjustments will affect the mass diagram already plotted. To avoid replotting the entire mass diagram, the original mass diagram should be plotted with 30 stations per line, beginning each line with the mass at 0 (zero) and the balance line in its relative position with the mass. See the example below:

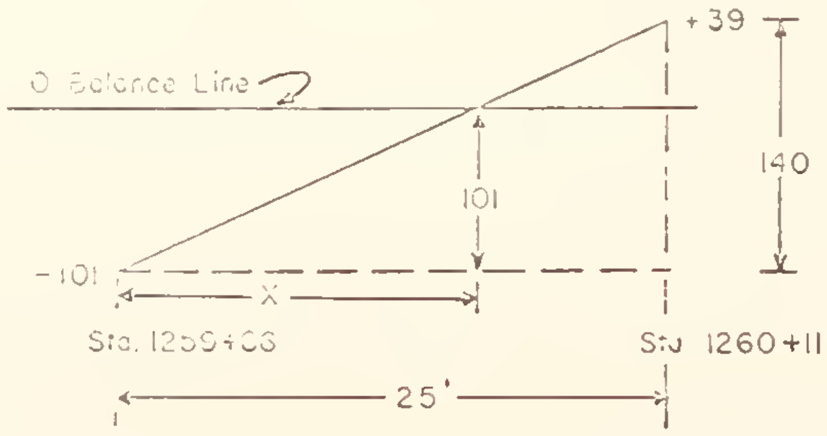


By plotting mass diagrams in this manner, grade changes will require replotting the mass curve only on the sheet where the grade changes are made. Subsequent sheets can be revised by simply adjusting the balance lines.

Mass diagrams used to compute haul usually require several sheets. These will not be included in the contract plans. Instead, the contract plans will include an abbreviated one-sheet mass diagram condensed from the original. Guidelines for preparing mass diagrams for the contract plans are presented in Chapter Fifteen.

Computing Balance Points

Once the grades have been finalized and the earthwork has been balanced, the designer should compute balance points and earthwork quantities for summarization. It is not necessary to compute earthwork quantities for each balance point. Several small balance points may be combined within distances of approximately 10 stations. Where a balance point falls between the stations listed on the computation sheet, compute the stationing using a straight-line relationship. For example, the stationing of the balance point between stations 1259 + 86 and 1260 + 11 (see the example computation sheet) is computed as follows:



Stationing of Balance Point = 1259+86 Plus X Feet

$$X = \frac{101}{140} \times 25'$$

$$X = 18.04'$$

Stationing of Balance Point = 1259+86+18' = 1260+04'

Compute the stationing of each balance point to the nearest tenth of a foot on the computation sheet and record to the nearest foot on the mass diagram and grading frame.

When the balance points have been documented, calculate the excavation quantities and the adjusted embankment quantities between balance points. These calculations should be checked to see that:

- Excavation equals adjusted embankment between each pair of adjacent balance points.
- The sum of the totals between balance points equals the sum of the sheet totals for the entire project.

The excavation and adjusted embankment quantities between splits should be recorded on the computation sheet and the mass diagram.

Computing Haul

Haul--to be computed in "mile yards" -- is represented by the areas between the mass curve and the balance line. To compute haul, measure the areas between balance points with a planimeter and convert the areas to mile yards by using a formula based on the plotting scales.

The following formula may be used:

$$\text{Mile yards per square inch} = \frac{\text{Stations per inch} \times \text{Cubic yards per inch}}{52.8}$$

Record the haul between balance points on the computation sheet and the mass diagram.

Unbalanced Splits

Unbalanced splits may occur at such points as county lines, city limits and special funding limits. In these instances the excavation is to be charged to the point of origin and the haul is to be charged to the point where the material is deposited. Within these unbalanced splits the quanties for excavation and adjusted embankment will not be equal.

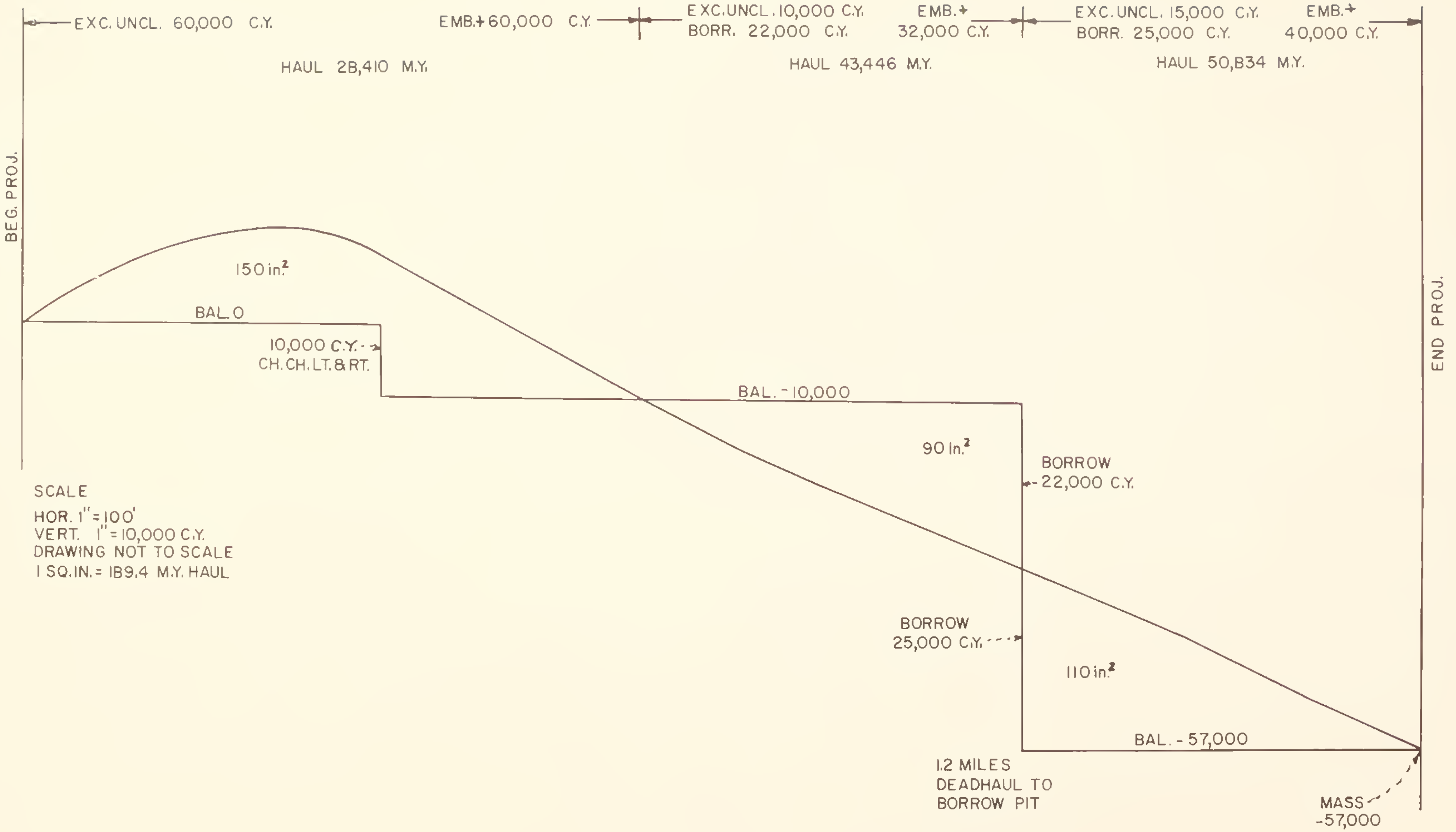
Borrow

When borrow is to be used from sources other than the roadway prism, the excavation and the haul are both charged to the section where the material is deposited.

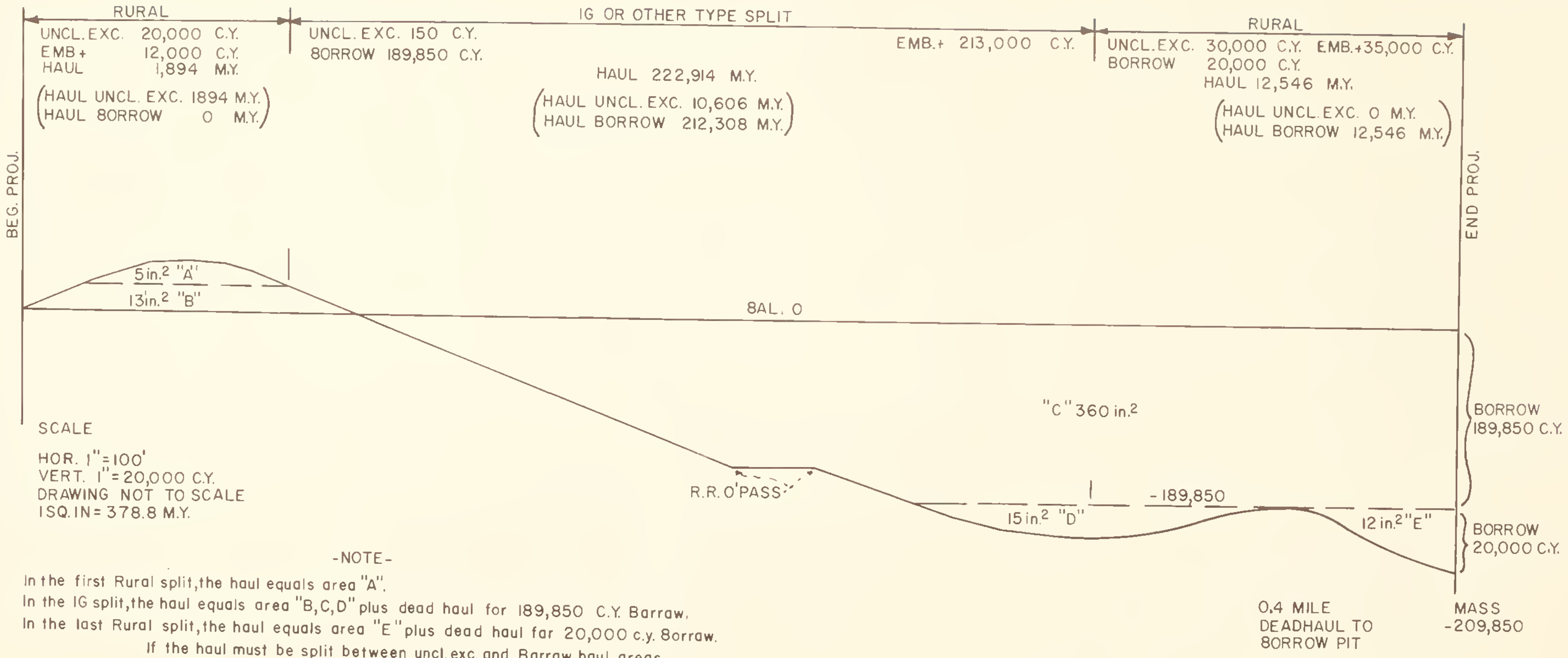
Deadhaul must be computed separately from the borrow source to the highway centerline and combined with the haul for distributing the material (as measured) with the planimeter).

When borrow is used, the balance line on the mass diagram should be adjusted downward at the stationing where the haul road intersects the centerline. The amount of downward adjustment should reflect the total amount of borrow.

TYPICAL HAUL COMPUTATION FOR BORROW



TYPICAL HAUL COMPUTATION FOR UNBALANCED SPLITS



-NOTE-

In the first Rural split, the haul equals area "A".
In the IG split, the haul equals area "B, C, D" plus dead haul for 189,850 C.Y. Borrow.
In the last Rural split, the haul equals area "E" plus dead haul for 20,000 c.y. Borrow.

If the haul must be split between uncl. exc. and Borrow haul areas "A", "B", & "D" would be uncl. exc. haul. Areas "C" & "E" and dead haul would be Borrow haul. Haul quantities above in parenthesis shows quantities split for Borrow and uncl. exc. haul.

DRAINAGE AND IRRIGATION

Chapter Seven

DRAINAGE AND IRRIGATION DESIGN

GENERAL CONSIDERATIONS

This chapter presents policies and criteria for the design of facilities to take care of surface and subsurface water. Included are policies and criteria for the design of:

- Pipe culverts
- Special drainage facilities
- Irrigation facilities
- Storm drains
- Underdrains

Three special sections at the end of the chapter set forth design policies for special-purpose large culverts, guidelines for measuring culvert excavation and a group of general reference tables.

PIPE CULVERTS

Nearly all drainage and irrigation facilities involve the use of some type of pipe culvert. Pipe culvert design requires determinations as to:

- Pipe material
- Pipe size
- Structural requirements
- Multiple pipe installation requirements
- Culvert End Treatments
- Culvert inlet and outlet protection
- Culvert lengths
- Culvert Bedding

Pipe Material

Pipes may be fabricated of concrete, steel or aluminum. Decisions as to the appropriate type of pipe material will be based on evaluation of the location of the project, existing soils conditions, proximity of fabrication plants and other pertinent factors. Provisions may be included to permit alternative bids for pipes of different materials. The designer will be advised in writing of these decisions.

In the case of reconstruction projects where existing pipes are salvageable and require lengthening, the additional lengths of pipe usually will be of the same material as the existing pipe. These special conditions will be identified in recommendations at the time of the field survey.

Pipe Size

The locations and sizes of pipe culverts will be determined in the field at the time of the location survey. Pipe sizes are to be based on the Burkli-Ziegler formula. Field personnel are furnished with tables, charts and instructions for making these determinations. The recommendations will be documented for use by the designer.

Where the drainage area exceeds 10,000 acres, or the flow exceeds 500 CFS, the Hydraulic Unit will conduct special studies to determine appropriate pipe size.

All new mainline pipe culverts must be at least 24" diameter. Approach culverts must be at least 18" diameter.

Structural Requirements for Corrugated Steel Pipe

Metal thickness is the principal measure of strength in corrugated steel pipe. The required metal thickness depends on these factors:

- Pipe size
- Shape of pipe
- Height of fill over pipe
- Dimensions of corrugations

Standard Sheet No. 701 shows the relationships between these factors. The tables show the minimum and the maximum permissible fill heights for each combination of pipe size and metal thickness. Fill height is measured from the top of the pipe to the finished roadway surface.

Unless otherwise directed, all CSP will have 2-2/3" x 1/2" corrugations. Under unusual conditions the larger 3" x 1" corrugations may be used, in which case the special design must be clearly specified on the plans.

Most culvert installations will be "round" pipe. Pipe arches should be used only where headroom (cover over pipe) is limited, or where local conditions make the flatter shape of the pipe arch more effective for carrying the water.

All CSP of 48" diameter and larger shall be elongated 5% out of round in a vertical plane. The values in parentheses in Standard Sheet No. 701 show maximum permissible fill heights for elongated pipes.

Structural Requirements for Structural Steel Plate Pipe Culverts

Normally, for culvert installations of 72" diameter and larger and for pipe arches of 7'0" S x 5'1" R and larger, structural steel plate pipe culverts will be specified for fabrication in the field.

Standard Sheet No. 702 provides criteria for minimum and maximum fill heights permitted with various combinations of pipe size and metal thickness. The designer must specify adequate metal thickness for each installation.

All SSPPC shall be elongated 5% out of round in a vertical plane. The values in parentheses show maximum permissible fill heights for elongated pipe.

Structural Requirements for Corrugated Aluminum Pipe

When corrugated aluminum pipe is to be specified or permitted as an alternative, the metal thickness requirements will be determined from Standards Sheet No. 703 for the particular conditions of pipe shape and height of fill.

Structural Requirements for CSP and SSPPC Under Railroads

Standard Sheet No.703 shows metal thickness requirements for CSP and SSPPC installations for various fill heights under railroads. Do not use these tables for normal highway installations.

ROUND AND ELONGATED C.S.P.

2 2/3" x 1/2" CORRUGATIONS Riveted, Welded or Helical Fabrication						
Pipe Diameter in inches	Minimum Fill Height (inches) To Top of Subgrade	MAXIMUM FILL HEIGHT (feet)				
		METAL THICKNESS IN INCHES				
		0.064	0.079	0.109	0.138	0.168
12	12	84	91			
15	12	67	73			
18	12	56	61			
24	12	42	46	59		
30	12	34	36	47		
36	12	28	30	39	41	
42	12	31	43	46(67)	48(70)	50(73)
48	12	27	37	45(58)	46(61)	47(64)
54	12		33	43(52)	44(54)	45(57)
60	12			43(47)	43(49)	44(51)
66	12			42	43	43(47)
72	12				41	43
78	12					39
84	12					35

3" x 1" CORRUGATIONS Riveted, Welded, Helical or Bolted Fabrication						
Pipe Diameter in inches	Minimum Fill Height (inches) To Top of Subgrade	MAXIMUM FILL HEIGHT (feet)				
		METAL THICKNESS IN INCHES				
		0.064	0.079	0.109	0.138	0.168
36	12	48	60	78(88)	89(106)	101(118)
42	12	41	51	64(76)	71(91)	79(101)
48	12	36	45	57(66)	61(80)	66(88)
54	12	32	40	52(59)	55(71)	59(79)
60	12	29	36	49(53)	51(64)	54(71)
66	12	26	33	47	49(58)	51(64)
72	12	24	30	44	47(53)	49(59)
78	12	22	28	41	46(49)	47(54)
84	12	21	26	38	45	46(51)
90	12	19	24	35	43	45
96	12	18	22	33	40	44
102	24	17	21	31	38	42
108	24		20	30	35	39
114	24		19	28	34	37
120	24			27	32	35

NOTES Maximum permissible fill heights over elongated pipes are shown in parentheses.

C.S.P. ARCHES

2 2/3" x 1/2" CORRUGATIONS Riveted, Welded or Helical Fabrication			
Pipe Dimensions Span x Rise (inches)	Minimum Fill Height (inches) To Top of Subgrade	Minimum Metal Thickness (inches)	Maximum Fill Height (feet)
18 x 11	18	0.064	13
22 x 13	18	0.064	12
25 x 16	18	0.064	10
29 x 18	18	0.064	10
36 x 22	18	0.064	9
43 x 27	18	0.064	9
50 x 31	18	0.079	8
58 x 36	18	0.109	8
65 x 40	18	0.109	8
72 x 44	18	0.138	8
79 x 49	18	0.168	8
85 x 54	18	0.168	9

3" x 1" CORRUGATIONS Riveted, Welded or Helical Fabrication			
Pipe Dimensions Span x Rise (inches)	Minimum Fill Height (inches) To Top of Subgrade	Minimum Metal Thickness (inches)	Maximum Fill Height (feet)
43 x 27	18	0.064	12
50 x 31	18	0.064	12
58 x 36	18	0.064	12
65 x 40	18	0.064	12
72 x 44	18	0.064	12
73 x 55	18	0.064	15
81 x 59	18	0.079	15
87 x 63	18	0.079	14
95 x 67	18	0.109	13
103 x 71	24	0.109	12
112 x 75	24	0.109	11
117 x 79	24	0.109	10
128 x 83	24	0.138	9

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

STRUCTURAL
REQUIREMENTS
FOR CSP

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 701

ROUND AND ELONGATED SSPPC

Pipe Diameter in Inches	Minimum Fill Height (inches) To Top of Subgrade	Maximum Fill Height (Feet)						
		Metal Thickness in Inches						
		0.109	0.138	0.168	0.188	0.218	0.249	0.280
60	12	43	62	81	93	106(111)	116(132)	126(144)
72	12	36	52	68	73(78)	79(93)	85(110)	91(120)
84	12	31	44	58	61(67)	65(79)	69(94)	72(103)
96	12	27	39	51	55(58)	57(69)	60(82)	62(90)
108	24	24	34	45	50	52(62)	54(73)	56(80)
120	24	22	31	41	47	49(56)	50(66)	52(72)
132	24	20	28	37	42	47(51)	48(60)	49(66)
144	24	18	26	34	39	45	46(55)	47(60)
156	24	17	24	31	36	43	45(50)	46(56)
168	24	15	22	29	33	40	44(47)	45(52)
180	24	14	21	27	31	37	44	44(48)
192	24		19	25	29	35	41	43
204	36		18	24	27	33	39	43
216	36			23	26	31	37	40
228	36			21	25	29	35	38
240	36				23	28	33	36
252	36					27	31	34

SSPP ARCHES

Pipe Dimensions Span x Rise (Ft. - In.)	Minimum Fill Height (inches) To Top of Subgrade	Minimum Metal Thickness (inches)	Maximum Fill Height (Feet)
6' - 1" x 4' - 7"	18	0.109	15
7' - 0" x 5' - 1"	18	0.109	15
7' - 11" x 5' - 7"	18	0.109	12
8' - 10" x 6' - 1"	24	0.109	11
9' - 9" x 6' - 7"	24	0.109	10
10' - 11" x 7' - 1"	24	0.109	9
11' - 10" x 7' - 7"	24	0.109	8
12' - 10" x 8' - 4"	24	0.109	8
13' - 3" x 9' - 4"	24	0.109	13
14' - 2" x 9' - 10"	24	0.109	12
15' - 4" x 10' - 4"	24	0.138	11
16' - 3" x 10' - 10"	36	0.138	11
17' - 2" x 11' - 4"	36	0.138	11
18' - 1" x 11' - 10"	36	0.168	9
19' - 3" x 12' - 4"	36	0.168	9
19' - 11" x 12' - 10"	36	0.168	8
20' - 7" x 13' - 2"	36	0.188	8

Notes

Maximum permissible fill heights over elongated pipes are shown in parentheses.

All pipes on this sheet -- 6" x 2" corrugations H-20 loading, Bolted Fabrication.

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

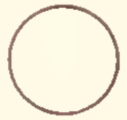
STRUCTURAL
REQUIREMENTS
FOR SSPPC

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 702

ROUND C.A.P.

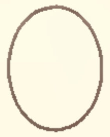


Pipe Diameter in inches	Minimum Metal Thickness (inches)						
	Fill Height In Feet						
	1-10	11-15	16-20	21-25	26-30	31-35	36-40
15	0.060	0.060	0.060	0.060	0.060	0.075	0.105
18	0.060	0.060	0.060	0.060	0.075	0.105	
21	0.060	0.060	0.060	0.075	0.105	0.135	
24	0.075	0.075	0.075	0.075	0.105	0.135	
30	0.075	0.075	0.075	0.105	0.135	0.164	
36	0.105	0.105	0.105	0.135	0.164		
42	0.105	0.105	0.135	0.164	0.164		

C.A.P. ARCHES

Pipe Dimensions Span x Rise (inches)	Minimum Metal Thickness (inches)		
	Fill Height In Feet		
	2-8	9-11	12-16
18 x 11	0.060	0.060	0.060
22 x 13	0.060	0.060	0.060
25 x 16	0.060	0.060	0.060
29 x 18	0.075	0.075	0.075
36 x 22	0.075	0.105	0.105
43 x 27	0.105	0.105	0.105
50 x 31	0.105	0.105	0.135
58 x 36	0.105	0.135	0.135
65 x 40	0.105	0.135	0.164
72 x 44	0.135	0.164	

ELONGATED C.A.P.



Pipe Diameter in inches	Minimum Metal Thickness (inches)				
	Fill Height In Feet				
	1-10	11-15	16-20	21-25	26-30
48	0.105	0.105	0.105	0.135	0.164
54	0.105	0.105	0.105	0.135	0.164
60	0.135	0.135	0.164	0.164	
66	0.135	0.135	0.164		
72	0.135	0.135	0.164		

NOTES

All pipes on this sheet -- H-20 Live Load

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

STRUCTURAL
REQUIREMENTS
FOR CAP

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 703

ELONGATED S.S.P.P.C.

FOR RAILROADS ONLY

Pipe Diameter in inches	MINIMUM METAL THICKNESS (inches)															
	FILL HEIGHT IN FEET															
	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-70	71-80	81-90	91-100
60	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.138	0.138	0.168	0.188	0.218	0.218
66	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.138	0.138	0.168	0.168	0.188	0.218	0.249
72	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.138	0.138	0.168	0.168	0.188	0.218	0.249	0.280
78	0.138	0.109	0.109	0.109	0.109	0.109	0.109	0.138	0.138	0.168	0.168	0.168	0.218	0.249	0.280	
84	0.138	0.109	0.109	0.109	0.109	0.109	0.109	0.138	0.138	0.168	0.168	0.188	0.218	0.249	0.280	
90	0.138	0.109	0.109	0.109	0.109	0.109	0.138	0.138	0.168	0.168	0.188	0.218	0.249	0.280		
96	0.168	0.109	0.109	0.109	0.109	0.138	0.138	0.138	0.168	0.188	0.188	0.218	0.249	0.280		
108	0.168	0.138	0.138	0.138	0.138	0.138	0.138	0.168	0.188	0.218	0.218	0.249	0.280			
120	0.168	0.138	0.138	0.138	0.138	0.138	0.168	0.188	0.218	0.218	0.249	0.280				
132	0.168	0.138	0.138	0.138	0.138	0.168	0.168	0.188	0.218	0.249	0.280	0.280				
144	0.188	0.168	0.138	0.138	0.168	0.168	0.188	0.218	0.249	0.280	0.280					
156	0.188	0.168	0.168	0.168	0.168	0.168	0.218	0.249	0.280	0.280						
168	0.188	0.168	0.168	0.168	0.168	0.188	0.218	0.249	0.280							
180	0.188	0.168	0.168	0.168	0.168	0.218	0.249	0.280								

ROUND C.S.P.

FOR RAILROADS ONLY

Pipe Diameter in inches	MINIMUM METAL THICKNESS (inches)									
	FILL HEIGHT IN FEET									
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
18	0.079	0.079	0.079	0.079	0.079	0.079	0.109	0.109	0.109	0.109
21	0.079	0.079	0.079	0.079	0.079	0.109	0.109	0.109	0.138	0.138
24	0.079	0.079	0.079	0.079	0.109	0.109	0.109	0.138	0.138	0.138
30	0.079	0.079	0.109	0.109	0.138	0.138	0.138	0.168*	0.168*	0.168*
36	0.109	0.109	0.109	0.138	0.168	0.168	0.168*	0.168*	0.168*	0.168*
42	0.109	0.109	0.138	0.168	0.168					

* Make a trench one diameter deep in orginal soil or in compacted fill.

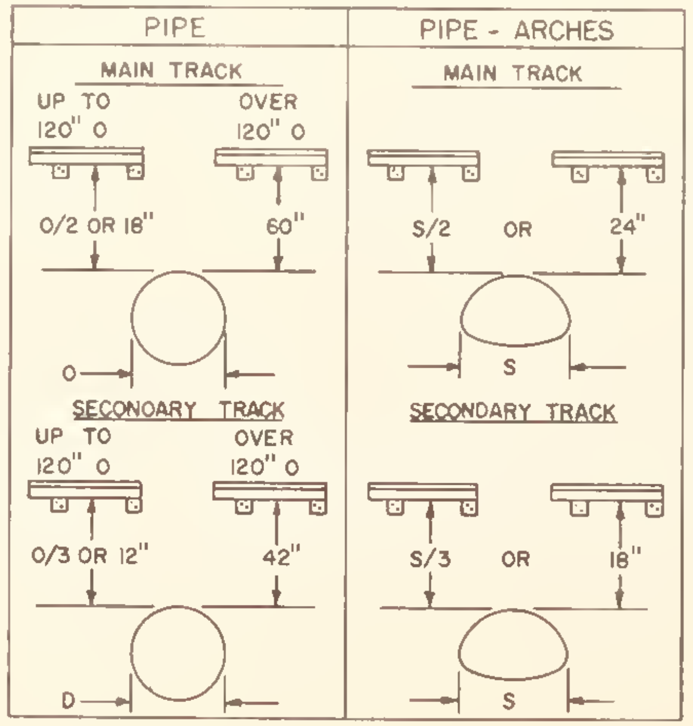
ELONGATED C.S.P.

FOR RAILROADS ONLY

Pipe Diameter in inches	MINIMUM METAL THICKNESS (inches)									
	FILL HEIGHT IN FEET									
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
42						0.168	0.168*	0.168*	0.168*	0.168*
48	0.138	0.138	0.168	0.168	0.168	0.168	0.168*	0.168*	0.168*	0.168*
54	0.168	0.168	0.168	0.168	0.168*	0.168*	0.168*	0.168*		
60	0.168	0.168	0.168	0.168	0.168*					
66	0.168	0.168	0.168*							
72	0.168	0.168*								

* Make a trench one diameter deep in original soil or in compacted fill.

MINIMUM HEIGHT OF COVER FOR CORRUGATED METAL STRUCTURES UNDER COOPER E-50 TO E-72 RAILROAD LOADINGS, FOR MAIN AND SECONDARY TRACKS.



C.S.P. ARCHES

FOR RAILROADS ONLY

Pipe Dimensions Span x Rise (inches)	MINIMUM METAL THICKNESS (inches)			
	FILL HEIGHT IN FEET			
	2	3-4	5-7	8-15
18 x 11	0.079	0.079	0.079	0.079
22 x 13	0.079	0.079	0.079	0.079
25 x 16	0.109	0.079	0.079	0.079
29 x 18	0.109	0.109	0.079	0.079
36 x 22	0.138	0.109	0.109	0.109
43 x 27	0.168	0.138	0.138	0.109
50 x 31		0.168	0.138	0.138
58 x 36			0.168	0.168
65 x 40				0.168
72 x 44				0.168

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

STRUCTURAL REQUIREMENTS FOR CSP AND SSPPC UNDER RAILROADS

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 704

Structural Requirements for Reinforced Concrete Pipe

Reinforced concrete pipes are identified by "class" numbers, depending on strength characteristics. Four classes are available -- Classes 2, 3, 4 and 5. The higher the number, the stronger the pipe. The table below identifies permissible fill heights for each class of pipe for Class C bedding.

MAXIMUM FILL HEIGHTS
(in feet)

Pipe Diameter (inches)	Pipe Class			
	2	3	4	5
12	9	13	17	26
15	8	13	17	27
18	9	13	17	26
21	9	13	17	26
24	9	13	18	26
27	9	13	18	27
30	9	13	18	27
33	9	13	18	27
36	9	12	17	26
42	9	14	17	27
48	10	13	18	28
54	10	13	17	27
60	10	13	18	28
66	10	13	19	28
72	10	14	19	28
78	10	15	19	
84	10	15	18	

If the fill height exceeds the permissible limits a metal pipe should be specified.

Multiple Pipe Installations

To provide an adequate waterway, it may be necessary to install two or more adjacent culverts at one location. Such an installation will be identified as a "double" or a "triple" installation at the station representing the center of the installation.

The spacing between outside edges of adjacent pipes normally will be a minimum of 4 feet and a maximum of 6 feet. If flared end terminal sections are used, there will be at least 2 feet between the outside ends of adjacent terminal sections.

Culvert End Treatments

Consideration should be made of special treatment required for the ends of culvert installations. Specific standard drawings and criteria for their applications are presented below.

Where fill slopes are flatter than 2:1, special culvert end sections will be specified according to these standard drawings:

STD. DWG. 46 - CMP Flared End Terminal Section (48" or less)
STD. DWG. 46 - CMP Arch F. E. T. S. (85" span x 54" rise or less)
STD. DWG. 47 - RCP Terminal Sections
STD. DWG. 48 - RCP Arch Terminal Sections (88" S x 54" R or less)

Where fill slopes are 2:1 or steeper, the culvert ends will be square and will extend 2 feet beyond the toes of slopes.

Culvert End Treatments (continued)

For the types and sizes of pipe culverts indicated below, special end treatments will be provided as indicated in the applicable standard drawings.

STD. DWG. 44 - Bevel on CSP Arch (58" S x 36" R and larger)
STD. DWG. 45 - Bevel on SSPP Arch (6'1" S x 4'7" R and larger)
STD. DWG. 44 - Step Bevel for SCP and SSPP (48" and larger)

If the pipe is skewed more than 15 degrees but not greater than 45 degrees from a right-angle crossing, the pipe ends will be designed and fabricated with a skew which will parallel the centerline. The type of bevel and the amount of skew will be identified on the plans.

Culvert Inlet and Outlet Protection

The Hydraulic characteristics of some drainage channels may require special protection for the roadway embankment at the inlets and outlets of culvert installations. Recommendations for special protection measures will be made at the time of the location survey or during subsequent field investigations. For pipes under 48" diameter, the designer should not provide for special protection unless he has received specific recommendations to do so.

For pipes with diameters of 48" and larger, and for pipe arches with equivalent cross-section areas, designers will provide the protective measures described in these standard drawings:

- STD. DWG. 30 - Cutoff walls at both ends.
  (See Standard Sheet No. 705 for quantity estimates)

- STD. DWGS. 31 and 32 - Concrete edge protection at inlet (See Standard Sheet No. 706 for quantity estimates)

- STD. DWG. 25 - Culvert riprap at outlet only
  (See Standard Sheet No. 707 for quantity estimates)

C S.P. and S.P.P.		
Size		C.Y. Conc.
Inch	Ft.	
48	4.0	1.13
54	4.5	1.20
60	5.0	1.27
66	5.5	1.34
72	6.0	1.42
78	6.5	1.49
84	7.0	1.57
90	7.5	1.65
96	8.0	1.73
102	8.5	1.82
108	9.0	1.90
114	9.5	1.98
120	10.0	2.07
126	10.5	2.15
132	11.0	2.24
138	11.5	2.33
144	12.0	2.42
150	12.5	2.51
156	13.0	2.60
162	13.5	2.69
168	14.0	2.79
174	14.5	2.88
180	15.0	2.98
192	16.0	3.18
198	16.5	3.28
204	17.0	3.38
210	17.5	3.48
216	18.0	3.59
228	19.0	3.80
240	20.0	4.01
252	21.0	4.24

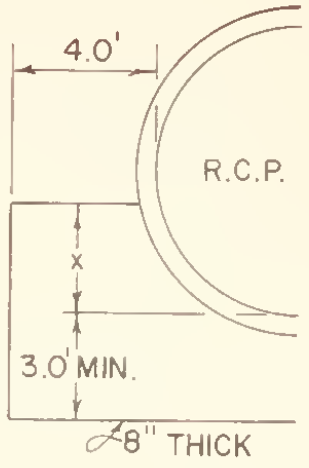
R.C.P. WITH FLARE END		
—	Single Pipe	Dual Pipe
Size	C.Y. *concrete	C.Y. *concrete
48"	5.2	7.4
54"	4.9	7.0
60"	4.7	8.6
72"	5.2	7.6
84"	5.7	8.5

* Quantity includes cutoff wall and Edge Protection

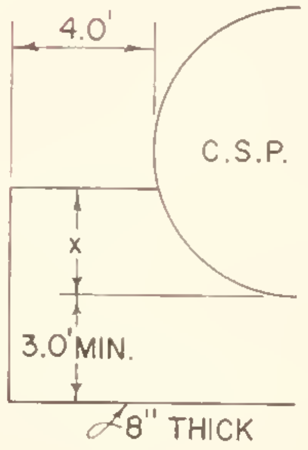
R.C.P.A. WITH FLARE END		
	Single Pipe	Dual Pipe
Size	C.Y. *concrete	C.Y. *concrete
58" x 36"	4.5	6.7
65" x 40"	4.7	7.1
72" x 44"	5.0	7.4
85" x 54"	5.1	7.9

* Quantity includes cutoff wall and Edge Protection

R.C.P. SQUARE ENDS		
Size	End Cutoff Wall	C.Y. Conc.
48"	42.75	1.06
54"	45.00	1.11
60"	47.25	1.17
66"	49.49	1.22
72"	51.74	1.28
78"	53.99	1.33
84"	56.23	1.39



HALF SECTS.



VEHICULAR UNDERPASS		
Span	Rise	C.Y. Conc.
12' - 2"	11' - 0"	2.43
13' - 10"	12' - 2"	2.62
14' - 10"	14' - 0"	2.72
15' - 8"	15' - 0"	2.80
16' - 5"	16' - 0"	2.82
17' - 3"	17' - 0"	3.17
19' - 1"	17' - 2"	3.37
20' - 4"	17' - 9"	3.46

R.C.P. ARCH SQUARE END		
Span	Rise	C.Y. Conc.
58	36"	1.14
65"	40"	1.18
73	45"	1.18
88"	54"	1.41

NOTE: 3' below flowline and 4' each side of inside of pipe.

C.S.A.P. (2 2/3" x 1/2" corr.)		
Span	Rise	C.Y. Conc.
58"	36"	1.12
65"	40"	1.19
72"	44"	1.25
79"	49"	1.29
85"	54"	1.44
C.S.A.P. (3" x 1" corr.)		
58"	36"	1.18
65"	40"	1.27
72"	44"	1.33
73"	55"	1.44
81"	59"	1.50
87"	63"	1.53
95"	67"	1.61
103"	71"	1.68
112"	75"	1.75
117"	79"	1.76
128"	83"	1.88

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MONTANA
DEPARTMENT OF HIGHWAYS

ESTIMATED QUANTITIES
FOR CUTOFF WALLS
(SEE STD. DWG. 30)

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 705

C.S.P. and S.P.P.			
Size		C.Y. Conc.	
Inch	Ft.	$1\frac{1}{2}$:1	2:1
48	4.0	1.75	2.35
54	4.5	1.93	2.59
60	5.0	2.11	2.82
66	5.5	2.30	3.05
72	6.0	2.49	3.29
78	6.5	2.67	3.52
84	7.0	2.87	3.76
90	7.5	3.06	4.01
96	8.0	3.26	4.25
102	8.5	3.46	4.50
108	9.0	3.65	4.75
114	9.5	3.85	5.0
120	10.0	4.06	5.25
126	10.5	4.27	5.5
132	11.0	4.45	5.76
138	11.5	4.68	6.02
144	12.0	4.89	6.28
150	12.5	5.10	6.55
156	13.0	5.32	6.82
162	13.5	5.54	7.09
168	14.0	5.75	7.36
174	14.5	5.98	7.63
180	15.0	6.20	7.91
192	16.0	6.66	8.47
198	16.5	6.88	8.76
204	17.0	7.11	9.04
210	17.5	7.35	9.33
216	18.0	7.58	9.62
228	19.0	8.05	10.22
240	20.0	8.54	10.83
252	21.0	9.02	11.44

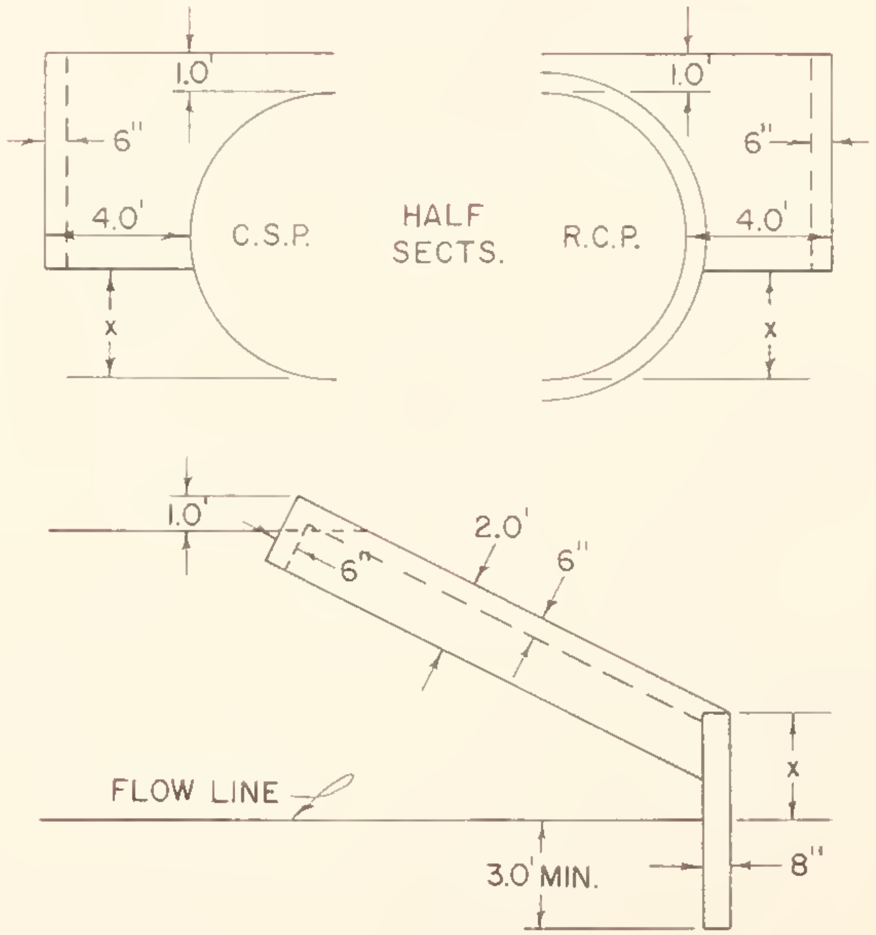
R.C.P. WITH FLARE END		
	Single Pipe	Dual Pipe
Size	C.Y. *concrete	C.Y. *concrete
48"	5.2	7.4
54"	4.9	7.0
60"	4.7	6.6
72"	5.2	7.6
84"	5.7	8.3

*Quantity includes cutoff wall and Edge Protection

R.C.P.A. WITH FLARE END		
	Single Pipe	Dual Pipe
Size	C.Y. *concrete	C.Y. *concrete
58" x 36"	4.5	6.7
65" x 40"	4.7	7.1
72" x 44"	5.0	7.4
85" x 54"	5.1	7.9

*Quantity includes cutoff wall and Edge Protection

VEHICULAR UNDERPASS		
Span	Rise	2:1 C.Y. Conc.
12' - 2"	11' - 0"	5.55
13' - 10"	12' - 2"	6.37
14' - 10"	14' - 0"	7.47
15' - 8"	15' - 0"	8.10
16' - 5"	16' - 0"	8.71
17' - 3"	17' - 0"	9.07
19' - 1"	17' - 2"	9.49
20' - 4"	17' - 9"	10.00



R.C.P. ARCH SQUARE ENDS			
Span	Rise	C.Y. Conc.	
		$1\frac{1}{2}$:1	2:1
$58\frac{1}{2}$"	36"	1.51	1.79
65"	40"	1.62	1.93
$73\frac{1}{2}$"	45"	1.75	2.08
88"	54"	1.99	2.37

C.S.A.P. (2 2/3" x 1/2" corrugation)			
Span	Rise	C.Y. Conc.	
		$1\frac{1}{2}$:1	2:1
58"	36"	1.76	2.10
65"	40"	1.90	2.27
72"	44"	2.04	2.45
79"	49"	2.26	2.71
85"	54"	2.31	2.78
C.S.A.P. (3" x 1" corrugations)			
58"	36"	1.64	1.95
65"	40"	1.75	2.09
72"	44"	1.89	2.26
73"	55"	2.10	2.52
81"	59"	2.28	2.74
87"	63"	2.45	2.95
95"	67"	2.63	3.16
103"	71"	2.81	3.39
112"	75"	3.01	3.63
117"	79"	3.17	3.82
128"	83"	3.40	4.10

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MONTANA
DEPARTMENT OF HIGHWAYS

ESTIMATED QUANTITIES FOR EDGE PROTECTION

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 706

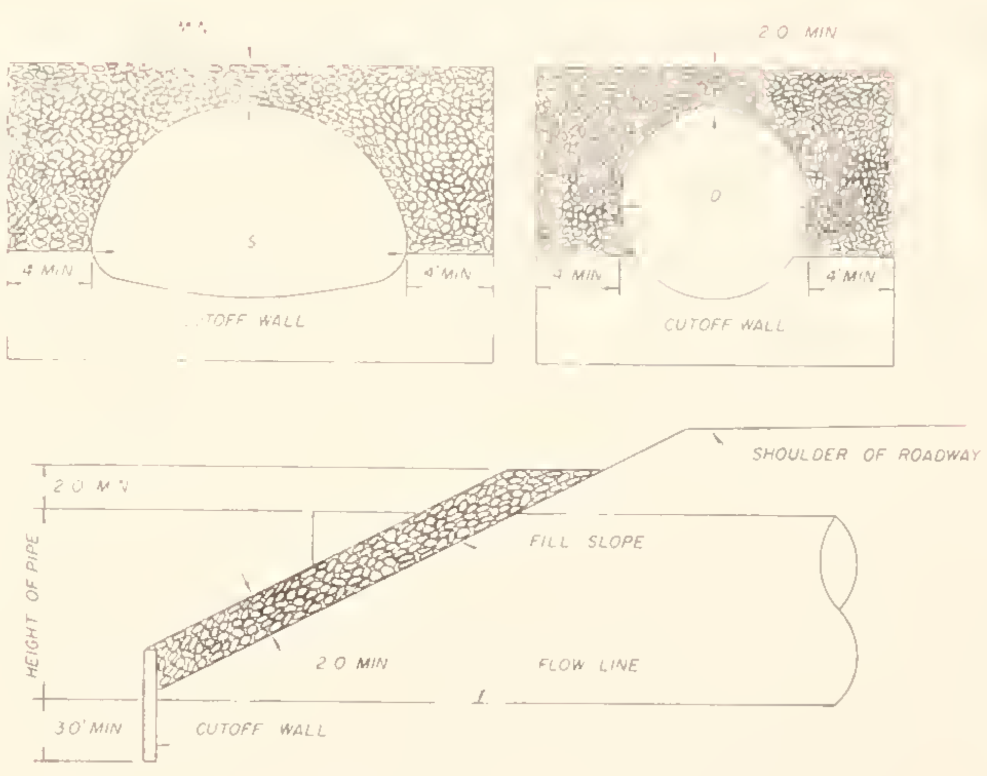
C.S.P. and S.P.P.			
Size		C.Y.	
Inch	Ft.	1½:1	2:1
48	4.0	7.46	9.26
54	4.5	8.20	10.17
60	5.0	8.96	11.11
66	5.5	9.73	12.07
72	6.0	10.52	13.04
78	6.5	11.32	14.04
84	7.0	12.14	15.06
90	7.5	12.98	16.10
96	8.0	13.83	17.15
102	8.5	14.70	18.23
108	9.0	15.58	19.33
114	9.5	16.49	20.45
120	10.0	17.40	21.58
126	10.5	18.34	22.74
132	11.0	19.29	23.92
138	11.5	20.35	25.24
144	12.0	21.23	26.34
150	12.5	22.41	27.79
156	13.0	23.32	28.92
162	13.5	24.24	30.06
168	14.0	25.48	31.60
174	14.5	26.43	32.78
180	15.0	27.39	33.97
192	16.0	29.67	36.80
198	16.5	30.67	38.05
204	17.0	31.68	39.29
210	17.5	33.06	41.01
216	18.0	34.45	42.73
228	19.0	36.62	45.42
240	20.0	39.17	48.58
252	21.0	41.78	51.81

R.C.P. ARCH SQUARE ENDS				
		C.Y.		
Span	Rise	1½:1	2:1	3:1
58½"	36"	6.32	7.48	11.09
65"	40"	6.82	8.46	11.97
73½"	45"	7.52	9.33	13.20
88"	54"	9.04	11.22	15.87

R.C.P. SQUARE ENDS		
	C.Y.	
Size	1½:1	2:1
48"	1.85	2.30
54"	2.33	2.89
60"	2.86	3.55
66"	3.45	4.27
72"	4.09	5.07
78"	4.78	5.93
84"	5.53	6.86

VEHICULAR UNDERPASS		
		C.Y.
Span	Rise	2:1
12' - 2"	11' - 0"	11.72
13' - 10"	12' - 2"	15.31
14' - 10"	14' - 0"	20.20
15' - 8"	15' - 0"	23.30
16' - 5"	16' - 0"	27.59
17' - 3"	17' - 0"	28.39
19' - 1"	17' - 2"	31.57
20' - 4"	17' - 9"	35.50

RANDOM RIPRAP



SEE SPECIFICATIONS FOR GRADATION, TYPES AND CONSTRUCTION METHODS

C.S.A.P. (22/3" x 1/2" corrugations)			
		C.Y.	
Span	Rise	2:1	3:1
58"	36"	8.44	11.94
65"	40"	9.13	12.92
72"	44"	9.97	14.10
79"	49"	11.08	15.66
85"	54"	11.42	16.15
C.S.A.P. (3" x 1") corrugations)			
58"	36"	8.32	11.76
65"	40"	9.63	13.62
72"	44"	9.86	13.94
73"	55"	11.11	15.71
81"	59"	12.04	17.02
87"	63"	12.85	18.17
95"	67"	13.75	19.44
103"	71"	14.72	20.82
112"	75"	15.77	22.29
117"	79"	16.56	23.41
128"	83"	17.80	25.17

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ESTIMATED QUANTITIES FOR CULVERT RIPRAP
(SEE STD. DWG. 25)

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 707

Determining Culvert Lengths

Cross drains should be drawn to scale on the templated cross section at the proper flowline. Previously described criteria for square ends or special end section treatment should be followed.

If the pipe is a right-angle crossing, the length may be scaled directly from the cross-section drawing. Keep these criteria in mind:

> Culverts are fabricated in multiples of 2-foot lengths. If the drawing scales to an odd number of feet, specify the next highest length which is a multiple of 2 feet.
>
> Flared end terminal sections are not bid separately -- they are included in the length of the culvert.
>
> Where beveled ends are called for, the measurement is along the pipe flowline.

If a pipe is skewed more than 5 degrees, the angle of skew should be drawn to scale on the cross sections. The ends of the culvert as shown graphically on the cross section should be extended forward and backward to intersect the skewed line. The actual length may then be scaled along the skewed line. If the skew is large enough and the cross sections are spaced close enough, greater accuracy may be provided by drawing the left half and the right half of culvert separately on adjacent cross sections and plotting the skewed line between the two cross sections.

The lengths of culverts under approaches can be scaled from simple sketches which accurately relate the ditch flowline to the approach elevation, width and side slopes.

Culvert Bedding

For most ordinary culvert installations less than 48" diameter, it will not be necessary to specify bedding materials unless specifically recommended.

For all culvert installations of 48" diameter and larger (and equivalent size arch culverts), it will be necessary to specify bedding materials in accordance with Standard Drawing Nos. 40 and 41.

Reference should be made to Standard Sheet No. 708 for guidance when estimating culvert bedding quantities for a specific installation.

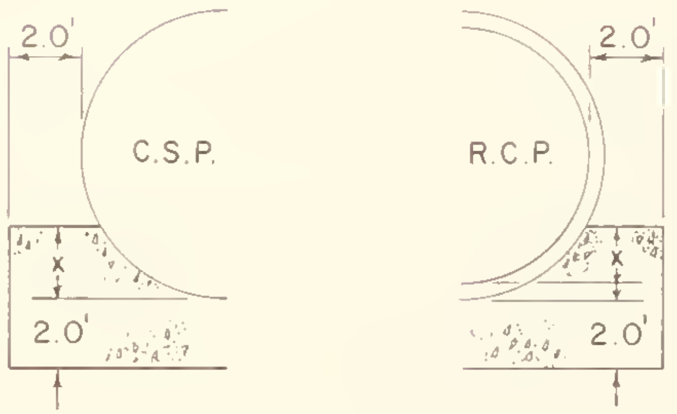
C.S.P. and S.P.P.		
Size		C.Y. Per ft.
Inch	Ft.	
48	4.0	1.1
54	4.5	1.2
60	5.0	1.3
66	5.5	1.3
72	6.0	1.4
78	6.5	1.5
84	7.0	1.6
90	7.5	1.7
96	8.0	1.7
102	8.5	1.8
108	9.0	1.9
114	9.5	2.0
120	10.0	2.1
126	10.5	2.2
132	11.0	2.2
138	11.5	2.3
144	12.0	2.4
150	12.5	2.5
156	13.0	2.6
162	13.5	2.7
168	14.0	2.8
174	14.5	2.9
180	15.0	3.0
192	16.0	3.2
198	16.5	3.3
204	17.0	3.4
210	17.5	3.5
216	18.0	3.6
228	19.0	3.8
240	20.0	4.0
252	21.0	4.2

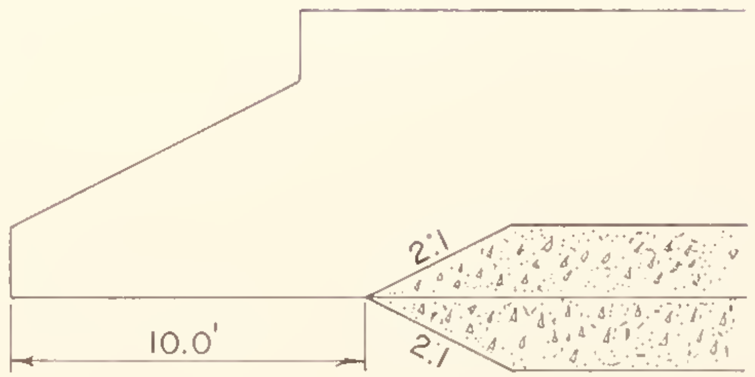
R.C.P. ARCH SQUARE ENDS			
Span	Rise	Shell Thick-ness	C.Y. Per ft.
58"	36"	5"	0.89
65"	40"	5½"	0.95
73"	45"	6"	1.05
88"	54"	7"	1.18

R.C.P. SQUARE ENDS	
Size	C.Y. Per Ft.
48"	0.71
54"	0.76
60"	0.81
66"	0.86
72"	0.91
78"	0.96
84"	1.01

C.S.A.P. (2 2/3" x 1/2" corrugations)		
Span	Rise	C.Y. Per ft.
58"	36"	0.79
65"	40"	0.86
72"	44"	0.91
79"	49"	0.94
85"	54"	1.12
C.S.A.P. (3" x 1" corrugations)		
58"	36"	0.84
65"	40"	0.93
72"	44"	0.98
73"	55"	1.08
81"	59"	1.15
87"	63"	1.16
95"	67"	1.26
103"	71"	1.33
112"	75"	1.39
117"	79"	1.39
128"	83"	1.53

VEHICULAR UNDERPASS		
Span	Rise	C.Y. Per Ft.
12' - 2"	11' - 0"	2.05
13' - 10"	12' - 2"	2.25
14' - 10"	14' - 0"	2.36
15' - 8"	15' - 0"	2.44
16' - 5"	16' - 0"	2.47
17' - 3"	17' - 0"	2.82
19' - 1"	17' - 2"	3.04
20' - 4"	17' - 9"	3.14





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ESTIMATED QUANTITIES
FOR CULVERT BEDDING
(SEE STD. DWGS. 40 & 41)

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STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 708

SPECIAL DRAINAGE FACILITIES

Embankment Protectors

Generally, embankment protectors as shown in Standard Drawing No. 29 should be installed at the corners of bridges and on high fills to control runoff. Typical installations are described below:

Four-lane divided highway on tangent

- Embankment protectors at 4 outside corners
- Bituminous curb at 4 inside (median side) corners
- Median drains with median inlet and cross drain or an outlet between structures with an embankment protector. Ditch blocks should be installed at the median inlet and bituminous curbs should be designed to prevent drainage from turning around the structure wingwalls.

Four-lane divided highway on curve

- Embankment protectors on 2 outside corners on low side of curve
- Bituminous curb at 2 inside (median side) corners on low side of curve
- Median drains same as on tangent section

Two-lane or four-lane with narrow median

- On tangent -- embankment protectors at 4 corners
- On curve -- embankment protectors at 2 corners on low side of curve.

When drainage flows toward the structure, embankment protectors should be placed as near the structure as possible.

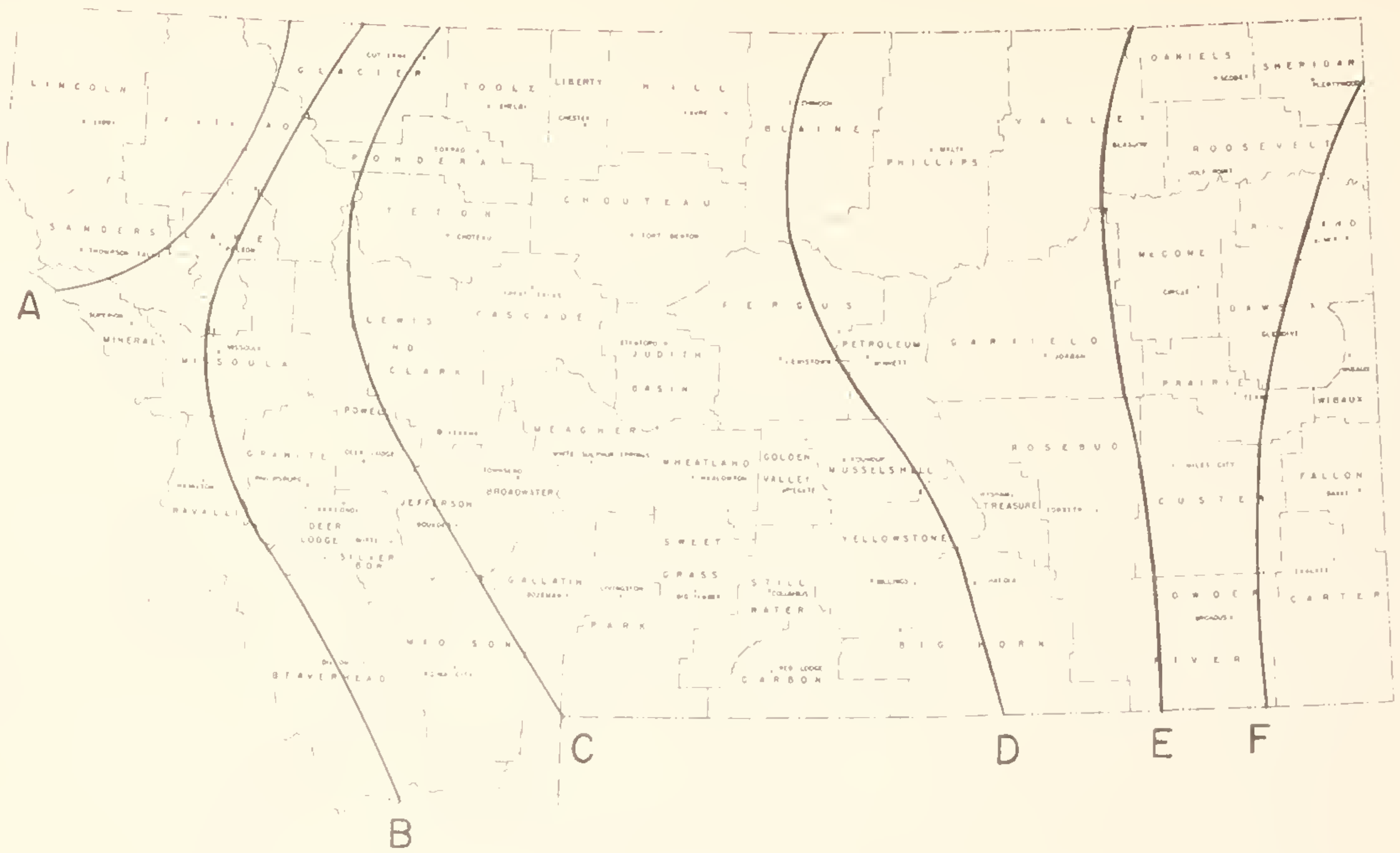
On long continuous sections of high fill, embankment protectors should be placed at intervals not exceeding the spacing shown on Standard Sheet No. 709.

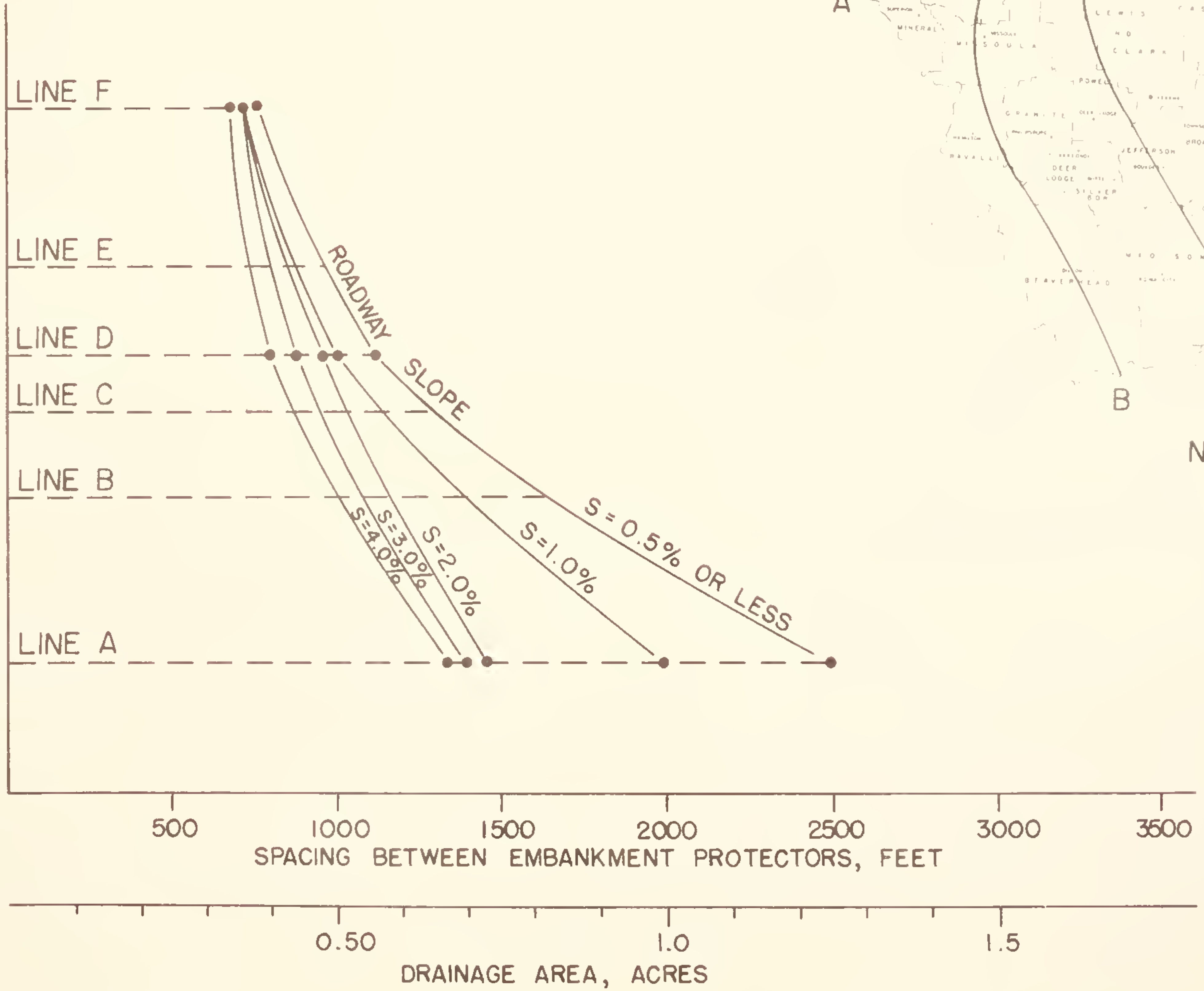
Standard Sheet No.710 prescribes appropriate spacings for median inlets.

If separate grading and surfacing contracts are proposed, embankment protector installations should be included with the surfacing contract.

Concrete Drainage Chute

The Concrete Drainage Chute described in Standard Drawing No. 28 may be used for backslope protection when the backslope intercepts a natural drainage coulee.





NOTE: SPACINGS ARE FOR 1/2 ROADWAY WIDTH ON TANGENT SECTIONS. WHERE PROTECTORS ARE NEEDED ON CURVE SECTIONS, COMPUTE AREA TO BE DRAINED BY PROTECTOR, AND CHECK THE ACREAGE WITH THE ACREAGE SCALE. IF THE COMPUTED ACREAGE IS GREATER THAN THE SCALE READING, REDUCE THE SPACING OF THE EMBANKMENT PROTECTORS.

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EMBANKMENT
PROTECTOR
SPACING

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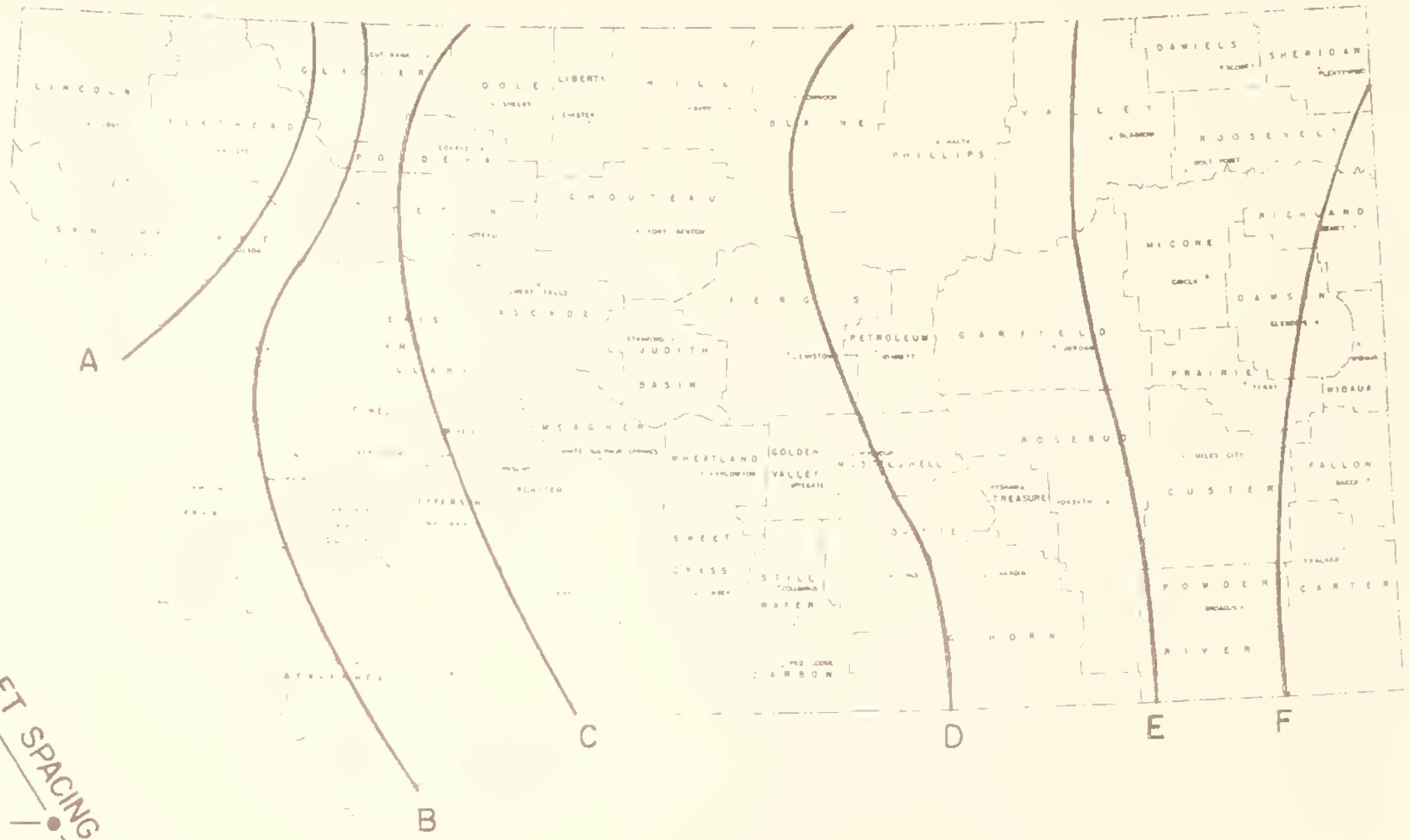
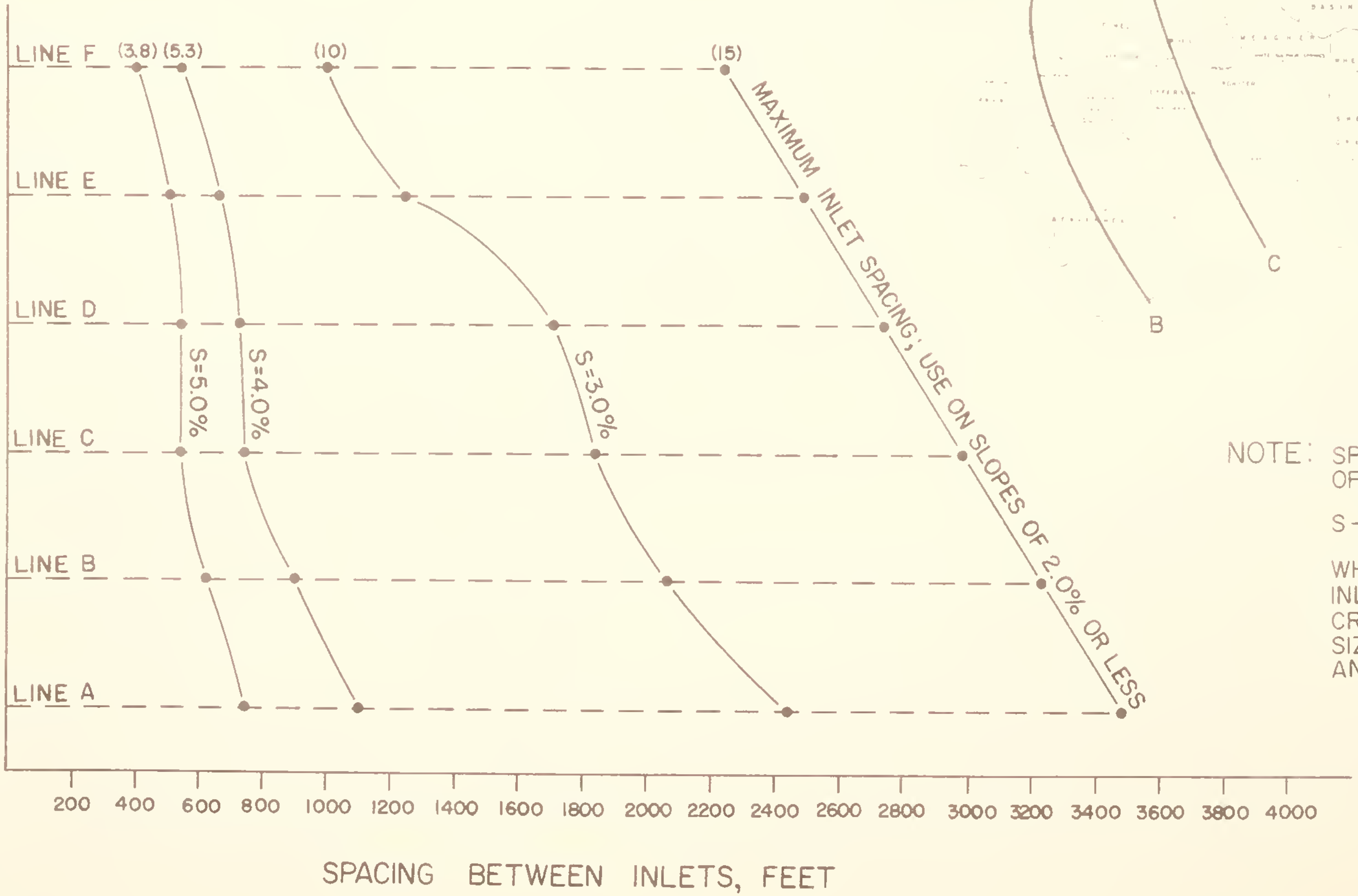
STANDARD SHEET NO. 709





NOTE: SPACINGS ARE FOR MEDIAN WIDTHS OF 76 FEET OR LESS.

S-GRADE OF ROADWAY IN PERCENT.

WHERE SIDE DRAINAGE & MEDIAN INLETS ARE IN COMBINATION, THE CROSS PIPES SHOULD BE OF ADEQUATE SIZE TO HANDLE BOTH SIDE DRAINAGE AND MEDIAN DRAINAGE.

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MEDIAN
INLET SPACING

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 710

IRRIGATION FACILITIES

Irrigation Pipe

Irrigation facilities will require water-tight pipe. In the summary of culverts, these pipes shall be recorded separately and identified as "Irrigation" or "Irrigation Syphon."

Special care should be taken when establishing and defining flowline elevations for irrigation installations. This is critical to effective operation. If there are unusual conditions, prepare clear, specific details on the plans.

Irrigation Syphon Pipe

Some irrigation pipes will be "syphons," where the pipes are bent down under the roadway with the inlet and outlet elevations higher than the centerline crossings. The Hydraulics Unit should be consulted for special design.

Division Boxes

When existing irrigation ditches are disturbed, it may be necessary to provide new division boxes. Alternatives for wooden and concrete division boxes are shown in Standard Drawing No. 52. Field recommendations will be made as to the type and size to be used.

Irrigation Ditch Relocations

Irrigation ditch relocations generally should be outside the right-of-way line. Ditch lining may be required in permeable soils.

To avoid irrigation ditch maintenance within the highway right-of-woy on projects with access control, irrigation culverts of 30" diameter and less should be extended to the R/W line.

Inlet and Outlet Headwalls

When specifically recommended for a particular irrigation installation, standard cast-in-place reinforced concrete headwalls shall be provided at the inlet end, the outlet end or both ends of the pipe culvert in accordance with Standard Drawing No. 34. For estimating purposes, quantities of concrete for various sizes of pipe are shown on the table of the Standard Drawing.

STORM DRAINS

Detailed design of extensive underground storm drains will be prepared by the Hydraulics Unit. Miscellaneous related details are described below.

Manholes

Standard Drawing No. 56 describes a combination manhole and catch basin to be cast-in-place at the prescribed locations.

Standard Drawing No. 57 illustrates the types of precast manholes (without catch basins) which may be specified for individual locations.

If none of these standard applications will adequately serve the particular conditions, a special manhole may be designed and detailed on the plans.

Inlets

Three types of storm drain inlets are described in Standard Drawings:

STD. DWG. NO. 53 - Drop Inlet Box and Cover

This inlet ordinarily would be placed at low spots and at street sections as necessary. It can sustain normal wheel loads.

STD. DWG. NO. 55 - Median Inlet and Cover

Three types of median inlets are described.

Type 1 - a small inlet box with a vertical outlet pipe to connect downward with a cross drain.

Type 2 - A slightly larger inlet box with a single horizontal pipe outlet.

Type 3 - The same as type 2, except with provisions for two horizontal pipe connections.

Type 1 provides for a 24" diameter pipe outlet. Types 2 and 3 have choices of 24", 30" or 36" diameters. The alternatives should be clearly identified on the plans. Tables on the Standard Drawing show estimated quantities of materials, but the bid item will be for the "Median Cover."

STD. DWG. NO. 54 - Curb Inlet Box and Cover

Standard Drawing No. 54 describes a standard curb inlet box and cover which may be specified for curbed urban streets where connection is to be made with underground storm drains.

If there is need to vary from the standard, the designer will prepare special details to be included with the plans.

UNDERDRAINS

Unusual subsurface water conditions frequently are encountered during field locations and soils surveys. Some form of underdrain may be recommended to alleviate those conditions.

Alternative types of underdrains include:

- Perforated CSP
- Semicircular Subdrain
- Open Joint Concrete Pipe
- Vitrified Tile

For each underdrain, the plans should clearly define the location, the type, the depth of placement and the filter material to be installed with the pipe.

See Standard Drawing No. 43 for a description of and criteria for filter material.

See Standard Drawing No. 42 for a description of a typical Semicircular Underdrain.

SPECIAL-PURPOSE LARGE CULVERTS

Large culverts frequently may be used for purposes other than to take care of drainage. They may serve as stockpasses or vehicular underpasses.

The designer will be advised when conditions warrant these installations. He should be guided by the following criteria.

Structural Steel Plate Pipe Stockpasses

A standard structural steel plate pipe designed specifically to serve as a stockpass is described in Standard Drawing No. 50. It should be specified only when justified by right-of-way negotiations.

The primary purpose of this structure is to serve as a stockpass. Design elevation should be so as to avoid water flow. Adjacent lower elevation culverts should be provided for drainage when necessary.

Installation design must provide at least 2 feet but not more than 6 feet of fill height to finished grade.

Length is measured along the flowline of the pipe. Try to design o right-angle crossing. If a skew is necessary, it should not exceed 15 degrees.

Bedding material is required under the structure as required for all SSPP.

Vehicular Underpasses

Two types of large culverts may be specified for vehicular underpasses:

- SSPP Arch Culvert (Std. Dwg. No. 51)
- Circular SSPPC

Ordinarily the arch-type vehicular underpass should be specified. Where the fill heights exceed the limitations for the arch-type, the circular pipe should be specified.

Bedding material should be specified as for all large culverts.

Standard Drawing No. 33 shows requirements for a backfill retainer and cutoff wall as well as criteria for surfacing the floor of the underpass.

Standard Drawing No. 31 shows concrete edge protection to be provided at all vehicular underpasses.

CULVERT EXCAVATION MEASUREMENT

Quantities of required culvert excavation shall be estimated for all culvert installations. Criteria for these measurements include:

- For culverts 42" diameter and less, the width of the culvert trench shall be equal to the outside diameter of the pipe plus 2 feet. The length of excavation shall extend the length of the pipe plus 2 feet.

- For culverts 48" diameter and larger the width of the culvert trench shall be the outside diameter plus 4 feet. The length of excavation shall be the length of culvert plus 4 feet.

- When bedding material is not specified, the bottom of the pipe shall be the bottom limit of culvert excavation.

- When bedding material is specified, the additional depth and width shall be measured as culvert excavation.

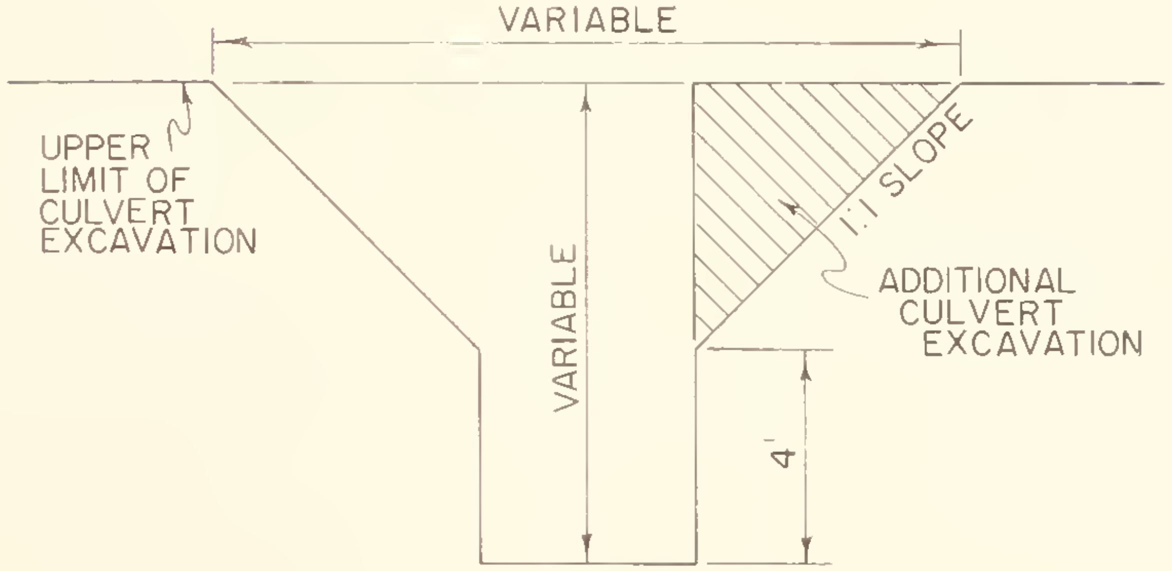
- In cut sections, the upper limit of culvert excavation shall be the top of the roadway prism. (It is assumed that roadway excavotion will be completed before culvert excavation is performed.)

- In fill sections, the upper limit of culvert excavation shall be the original ground line.

- Excavation for division boxes, cutoff walls and other minor structures normally will not be measured separately, but be included in other bid items.

- To determine the wall thickness of concrete pipe for estimating culvert excavation limits, the inside diameter in feet plus one equals the shell thickness in inches. E.G., for 60" RCP the shell thickness equals 5 + 1 = 6 inches. Outside diameter = 6 feet.

- In design of rural projects, additional quantities of culvert excavation will be provided for pipe installations requiring a trench with a depth greater than 4 feet. The additional quantities will be required to provide for sloping the sides of the excavation from a point 4 feet above the bottom of the trench. Quantities of culvert excavation to provide for the angle of repose will be based on a 1:1 slope.


VARIABLE
UPPER LIMIT OF CULVERT EXCAVATION
VARIABLE
1:1 SLOPE
ADDITIONAL CULVERT EXCAVATION
4'

GENERAL REFERENCE TABLES

The standard sheets on the following pages show general reference tables used by designers.

Standard Sheet No. 711 shows the cross-section areas (in square feet) of all round pipe and pipe arches commonly used. This sheet should be used when comparing the waterway openings of various sizes and shapes of pipes.

Standard Sheet No. 712 shows equivalent gages and metal thicknesses (in inches) of aluminum and steel pipe. This sheet may be needed by designers during the current transition from specifying pipe by gages to specifying pipe by metal thicknesses.

Standard Sheet No. 713 shows the areas and dimensions for pipe ends. Data on this sheet served as bases for the calculation of the estimated quantities on other standard sheets in this chapter.

STRUCTUAL PLATE PIPES
&
STRUCTUAL PLATE PIPE ARCHES

Raund Pipe Diameter	Pipe Arch Dimensians (Span x Rise)	Cross Sections Area (square feet)
60"		19.6
	6'1" x 4'7"	22.0
66"		23.8
	6'4" x 4'9"	24.0
	6'9" x 4'11"	26.0
	7'0" x 5'1"	28.0
72"		28.3
	7'3" x 5'3"	31.0
	7'8" x 5'5"	33.0
78"		33.2
	7'11" x 5'7"	35.0
	8'2" x 5'9"	38.0
84"		38.5
	8'7" x 5'11"	40.0
	8'10" x 6'1"	43.0
90"		44.2
	9'4" x 6'3"	46.0
	9'6" x 6'5"	49.0
96"		50.3
	9'9" x 6'7"	52.0
	10'3" x 6'9"	55.0
102"		56.7
	10'8" x 6'11"	58.0
	10'11" x 7'1"	61.0
108"		63.6
	11'5" x 7'3"	64.0
	11'7" x 7'5"	67.0
114"		70.9
	11'10" x 7'7"	71.0
	12'4" x 7'9"	74.0
	12'6" x 7'11"	78.0
120"		78.5
	12'8" x 8'1"	81.0
	12'10" x 8'4"	85.0
126"		86.6
	13'5" x 8'5"	89.0
	13'11" x 8'7"	93.0
132"		95.0
	14'1" x 8'9"	97.0
	14'3" x 8'11"	101.0
138"		103.9
	14'10" x 9'1"	105.0
	15'4" x 9'3"	109.0
	15'6" x 9'5"	113.0
144"		113.1
	15'8" x 9'7"	118.0
	15'10" x 9'10"	122.0
150"		122.7
	16'5" x 9'11"	126.0
	16'7" x 10'1"	131.0
156"		132.7
162"		143.1
168"		153.9
174"		165.1
180"		176.7

PIPE & PIPE ARCHES

Raund Pipe Diameter	Pipe arch Dimensians (Span x Rise)	Cross Sections Area (square feet)
	18" x 11"	1.1
	22" x 13"	1.6
18"		1.8
	29" x 18"	2.8
24"		3.1
	36" x 22"	4.4
30"		4.9
	43" x 27"	6.4
36"		7.1
	50" x 31"	8.7
42"		9.6
	58" x 36"	11.4
48"		12.6
	65" x 40"	14.3
54"		15.9
	72" x 44"	17.6
60"		19.6
72"		28.3
84"		38.5

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CROSS SECTION AREAS
OF ROUND PIPE
AND PIPE ARCHES

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 711

STEEL PIPE

Equivalent Metal Thicknesses and Gages	
Metal Thickness (inches)	Gage
0.064	16
0.079	14
0.109	12
0.138	10
0.168	8
0.188	7
0.218	5
0.249	3
0.280	1

ALUMINUM PIPE

Equivalent Metal Thicknesses and Gages	
Metal Thickness (inches)	Gage
0.060	16
0.075	14
0.105	12
0.135	10
0.164	8

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EQUIVALENT GAGE AND
METAL THICKNESS
(CORRUGATED METAL PIPE)

APPROVED

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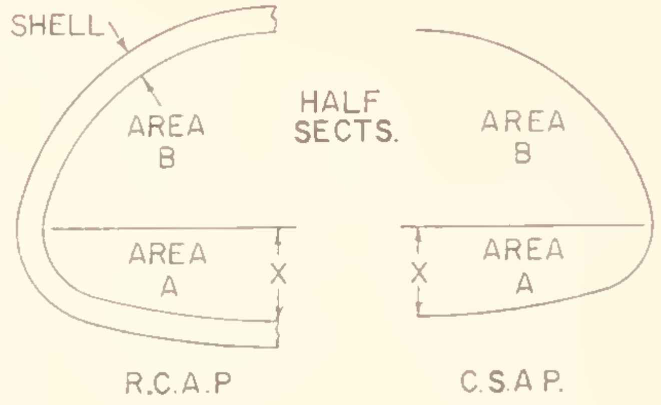
STANDARD SHEET NO. 712

C.S.P. and S.P.P.				
Diam. (in.)	Diam. Ft.	X Dist. (Ft.)	Area B Vert. (Sq. Ft.)	Tot. Area Vert. (Sq. Ft.)
48	4.0	1.0	10.11	12.57
54		1.125	12.80	15.90
60	5.0	1.250	15.80	19.63
66		1.375	19.11	23.76
72	6.0	1.500	22.75	28.27
78		1.625	26.70	33.18
84	7.0	1.750	30.96	38.48
90		1.875	35.54	44.18
96	8.0	2.000	40.44	50.27
102		2.125	45.65	56.75
108	9.0	2.250	51.18	63.62
114		2.375	57.02	70.88
120	10.0	2.500	63.19	78.54
126		2.625	69.66	86.59
132	11.0	2.750	76.45	95.03
138		2.875	83.56	103.87
144	12.0	3.000	90.99	113.10
150		3.125	98.73	112.72
156	13.0	3.250	106.78	132.73
162		3.375	115.16	143.14
168	14.0	3.500	123.84	153.94
174		3.625	132.85	165.13
180	15.0	3.750	142.17	176.71
192	16.0	4.000	161.75	201.06
198		4.125	172.03	213.82
204	17.0	4.250	182.61	226.98
210		4.375	193.51	240.53
216	18.0	4.500	204.72	254.47
228	19.0	4.750	228.10	283.53
240	20.0	5.000	252.74	314.16
252	21.0	5.250	278.65	346.36

R.C.P.				
Size	Shell Thick-ness	X Dist. (Ft.)	A Area (Sq.Ft.)	Tot. Inside Area (Sq.Ft.)
48"	5"	0.9	2.12	12.57
54"	5½"	1.0	2.63	15.90
60"	6"	1.1	3.20	19.63
66"	6½"	1.2	3.83	23.76
72"	7"	1.3	4.51	28.27
78"	7½"	1.4	5.25	33.18
84"	8"	1.5	6.05	38.48



AREAS FOR R.C.A.P.								
Span	Rise	Inside Area (Sq. Ft.)	Shell Thick-ness	X Dist. (Ft.)	Area Below X (Sq.Ft.)			Area Above X Incl. Shell (Sq. Ft.)
					A	Shell	Total	
58"	36"	11.4	5"	1.18	4.93	2.84	7.77	9.45
65"	40"	14.3	5 1/2"	1.30	6.26	3.48	9.74	11.69
73"	45"	17.7	6"	1.47	7.59	4.24	11.83	14.56
88"	54"	25.6	7"	1.77	11.07	5.93	17.00	20.74

C.S.A.P. (2 2/3" x 1/2" corrugations)				
Span	Rise	X Dist. (inches)	Area B Vert. (Sq. Ft.)	Tot. Area Vert. (Sq.Ft.)
58"	36"	9 1/4	8.29	11.4
65"	40"	10 1/2	10.48	14.3
72"	44"	11 3/4	12.34	17.6
79"	49"	13 1/4	13.75	21.3
85"	54"	14 1/2	20.00	25.3
C.S.A.P. (3" x 1" corrugations)				
58"	36"	13	7.00	11.4
65"	40"	14 3/4	8.93	14.3
72"	44"	16 1/4	10.50	17.6
73"	55"	21	13.33	22
81"	59"	21 1/2	16.28	26
87"	63"	22	19.13	31
95"	67"	22 1/2	22.71	35
103"	71"	23	26.52	40
112"	75"	23 1/2	30.81	46
117"	79"	24	34.59	52
128"	83	24 1/2	40.01	58

VEHICULAR UNDERPASS				
Span	Rise	X Dist (Ft.)	Area A Vert. (Sq. Ft.)	Tot. Area Vert. (Sq.Ft.)
12' - 2"	11' - 0"	3.709	36.84	107.61
13' - 10"	12' - 2"	3.820	42.95	135.39
14' - 10"	14' - 0"	3.870	46.85	168.82
15' - 8"	15' - 0"	3.957	51.21	191.86
16' - 5"	16' - 0"	3.838	52.41	218.96
17' - 3"	17' - 0"	4.756	67.51	238.91
19' - 1"	17' - 2"	4.794	74.70	265.29
20' - 4"	17' - 9"	4.785	80.33	294.68

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DEPARTMENT OF HIGHWAYS

AREAS AND DIMENSIONS
FOR PIPE ENDS

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STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 713

HIGHWAY INTERSECTIONS

Chapter Eight

HIGHWAY INTERSECTIONS

GENERAL CONSIDERATIONS

Criteria and procedures for the design of highway intersections are discussed in terms of three basic types:

- At-grade intersections
- Grade separations
- Interchanges

Good intersection design will contribute to the safety and convenience of highway operation. For most rural access approaches the criteria are quite simple. Where larger volumes of traffic are involved, more factors must be considered, and the criteria become more complex.

AT-GRADE INTERSECTIONS

Since at-grade intersections are not permitted on the Interstate System, the following criteria are restricted to application on Primary and Secondary projects.

Private Approaches

Generally, it is the policy of the Department to replace existing approaches where highways are to be reconstructed. Where highways are on new locations, approaches will be provided as required by the abutting property owners providing that the approach is not a safety hazard.

Care should be taken to avoid excessive numbers of approaches. Keep in mind that:

- Approaches are expensive -- including costs of excavation, surfacing materials and pipe culverts.
- Some existing farm entrances and approaches may have outlived their usefulness and may no longer be required.
- Each approach presents a potentially hazardous conflict with highway traffic, particularly when the volume of traffic is large.
- Each approach represents an obstruction in the recovery area.

Recommendations for private approach locations may be included with the location survey, In some cases, the need for a private approach may be obvious from the plan sheet layout. If there is any question about the need for an approach, do not include the approach in the initial design. The situation should be investigated during a field inspection. Final determinations of the needs for approaches will be documented at the time of right-of-way negotiations.

Public Roads

Approaches will be designed for all public road intersections. Because these roads usually carry more traffic than private roads, the design geometrics become more significant. Short relocations may be desirable, and traffic turning lanes and channelization may be warranted. These are discussed later.

Commercial Entrances

Because of the variety of conditions and circumstances related to providing access to commercial establishments, the Department has prepared a special manual entitled "Approach Standards for Montana Highways." This manual principally is a guide for abutting property owners desiring access to existing highways. However, the criteria and examples are equally applicable to new highway construction. Designers should be guided by this manual.

Right-of-Way Considerations

Regardless of previous judgments and decisions, the right-of-way considerations resulting from negotiations with owners serve as the final authority for the locations of approaches. Designers will be given copies of these documents. They should be reviewed thoroughly to ensure that the design plans are consistent with the commitments to the landowners.

Geometric Criteria

Geometric criteria for a typical road approach are shown in Standard Drawing No. 103. All approaches should be designed and constructed according to this standard unless special recommendations are made for individual locations. Variations from the standard must be identified on the plans.

The location of each approach should be reviewed to ensure that sight restrictions do not create a hazardous condition. If possible, adjust the location to avoid sharp blind curves and deep cut or fill sections. Approaches should not be hidden behind crest vertical curves.

To avoid costly earthwork, approaches should not be located off high fills, especially where the natural ground falls away from the mainline.

A landing zone should be provided adjacent to the highway shoulder. This area should be at least 75 feet long for major public roads and at least 25 feet long for other private approaches. Landing areas should be designed on a slope of .03 feet per foot. Grades beyond the landing zone should not exceed the 10% maximum.

Approach intersection angles should be skewed no more than 30° from a right-angle approach. Slight relocations of connecting roads may be necessary to meet this requirement.

Approach Surfacing

All approaches on bituminous surfaced projects will be bituminous surfaced to the right-of-way line. The types and amounts of approach surfacing for special conditions will be determined during plan-in-hand inspections.

Unless otherwise directed, approach surfacing depths will be:

0.125'	Compacted Plant Mix Bituminous Surfacing
0.20'	Average Depth Compacted Top Surfacing Type "A" Leveling Course
0.50'	Compacted Crushed Base Course Type "A"

Standard Sheet No. 901 shows a standard approach layout sketch, a typical section and a table of surfacing quantities for various approach lengths -- to be used for estimating purposes.

Channelization

Consideration should be given to provisions for traffic channelization for the following conditions:

- Left turn bays at median openings in divided multilane highways.
- Widened roadway sections with left turn bays or bypass lanes at junctions with major highways.
- Acceleration and deceleration lanes at junctions with major highways.
- Special turnouts at bus stops, mail boxes and other unusual conditions.

Traffic volumes and turning movements usually will dictate the need for special channelization. The Traffic Engineer should be consulted prior to plan-in-hand inspection to identify specific channelization needs and to recommend layouts.

Special channelization provisions must be detailed on the plans.

GRADE SEPARATIONS

When designing grade separations, keep in mind the possibility that the grade separations may be selected as future interchange sites. To facilitate the design and construction of possible future interchanges, the interchange criteria for grade, alignment and sight distance should be considered in the design of grade separations.

Standard bridge clearances are specified in Chapter Twelve.

INTERCHANGES

Most interchanges remaining to be constructed in Montana will be the "Diamond" type. Requirements for specific interchanges, such as locations and general geometrics, are defined during the planning process.

The following discussion is limited principally to the "Diamond" type interchange.

Preliminary Layout

Based on the general criteria established and approved during the planning process, a preliminary layout should be prepared defining the location and approximate geometrics of the interchange. Specific items to be included on the layout are enlargements of ramp terminals (1" = 50'), traffic diagrams showing turning movements, and the name of the interchange.

The preliminary layout does not require refined details -- stationing may be scaled, grades to the nearest percent, traverses need not be closed. Ordinarily, the layout will be prepared on a brownline transparency with contours an the back. The basic purpose is to identify and clearly illustrate the layout in relation to proposed terrain contours so as to verify that the proposed design is both feasible and economical.

A typical preliminary layout is shown on the next page.

Layout Review

Prior to the preliminary plan-in-hand (P.I.H.) inspection, the preliminary layouts should be reviewed by the Traffic Engineer and the Federal Highway Administration. Recommended changes should be incorporated in the layout.

At the time of the preliminary P.I.H. inspection, the layouts are further reviewed in the field, particularly with regard to alignments and grades.

Detailed Design

Following preliminary P.I.H. approval, the detailed design of the interchange will be initiated. The detailed design will include:

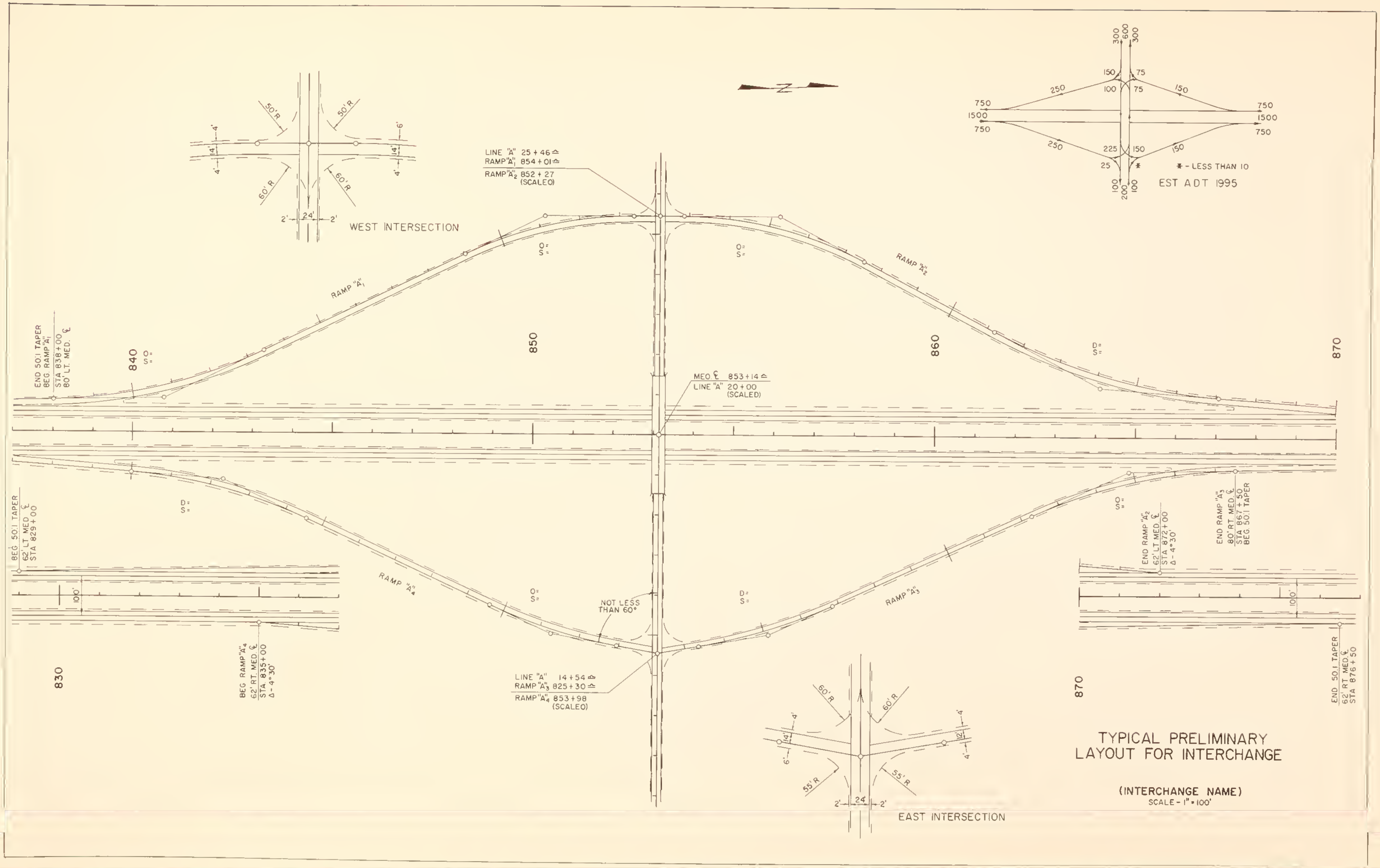
- Precise identification of ramp alignment and curvature with computed ties and traverse closures.
- Precise identification of elevations and grades to the nearest 0.01 ft.
- Precise identification of crossroad alignment and grades with ties to the extremeties of construction
- Identification of proposed structures and structure clearances.

Examples of detailed plan and profile sheets for interchanges are shown in the model plans in Chapter Fifteen.

Contour Grading Plans

It has been found that better looking interchanges can be constructed from contour grading plans rather than from plan and profile sheets. Although the plan and the profile provide rigid controls for the riding surface, the grading of the areas adjacent to the roadway surfaces should be pleasing in appearance with smooth flowing lines that blend with the countryside. Sharp breaks and harsh lines should be avoided. When locating ramps, adequate room should be provided to permit rounding of slopes between the ramps and the main roadway.

Contour grading plans should be prepared consistent with the example in the model plans in Chapter Fifteen. Do not show contour lines across the roadway surface -- they should commence and end at the roadway and ramp shoulders.



TYPICAL PRELIMINARY LAYOUT FOR INTERCHANGE

(INTERCHANGE NAME)
SCALE - 1" = 100'

Design Criteria

The following criteria will apply to the design of interchanges:

- Crossroad Width -- The crossroad width will be based on the traffic anticipated in the design year in accordance with current approved design standards.

- Crossroad Surfacing (Local road over) -- At each crossroad where the local road goes over a freeway, the crossroad will be paved with a minimum of 0.20' of plant mix surfacing between and including the ramp terminals. From the ramp terminals to the ends of construction, the surfacing will correspond to that anticipated on the local road in the design year.

- Crossroad Surfacing (Freeway over) -- In general, crossroads under a freeway will have surfacing to conform with design year requirements for the local road. However, in all instances where the crossroad design year ADT is 100 or greater, at least 0.20' of plant mix surfacing will be provided between and including the ramp terminals.

- Ramp Width -- All exit ramps will be 24 feet wide. The widths of entrance ramps will be as follows:

Design Year ADT	Width
Less than 100	18 feet
100 - 199	20 feet
200 - 300	22 feet
More than 300	24 feet

- Ramp Surfacing -- Ramp surfacing will correspond to that provided on the crossroad except that where the crossroad is not paved, the ramps will have 0.20' of plant mix surfacing and base as required. The mainline structural section will be reduced at the gore or nose, and if the crossroad is not paved the ramp paving will end at the cattleguard.

- Cattle Guards -- Where cattle guards are required on ramps, try to provide at least 150 feet between the crossroad and the cattle guard.

- Acceleration and Deceleration Lanes -- Illustrated examples and detailed design criteria for acceleration and deceleration lanes are shown on Standard Sheet No. 801.

- Frontage Roads -- Where frontage roads intersect crossroads, try to provide at least 300 feet between the frontage road and the ramp terminal.

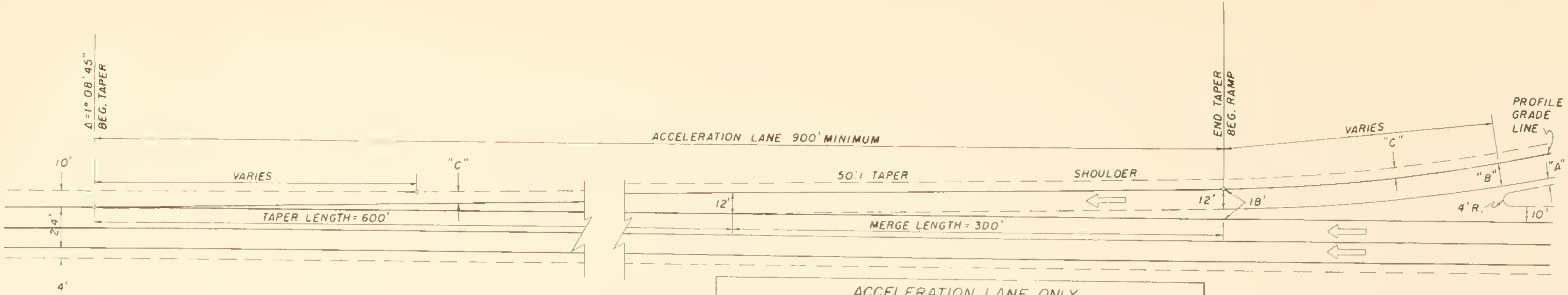
- Sight Distance At Ramp Terminals -- A vehicle stopped at a ramp terminal must have adequate sight distance along the crossroad to safely make a left turn onto the crossroad. The critical factor is the ability to see the top of an oncoming vehicle from the left as it crosses the interchange structure. Usually the structure will be on a crest vertical curve. The designer must provide adequate values for distance. The required sight distance varies with the design speed of the crossroad and the type of vehicle. The criteria for providing sight distance at ramp terminals are shown on Standard Sheet No. 802.

The minimum distances shown under "Normal Conditions" should be used at most locations. At rural locations with relatively low traffic volumes and little probability of frequent heavy truck's, the lesser sight distances shown under "Passenger Cars and Light Trucks Only" may be used. At interchange areas near industrial or commercial complexes (logging sites, cement plants, refineries, etc.) longer sight distances must be provided as shown in the column for "Industrial Areas-Large Trucks".

The sight distances shown on Standard Sheet No. 802 should not be confused with minimum stopping sight distance which is based on an object height of 6 inches. When the absolute minimum stopping sight distance is provided on crossroad vertical curves, the "left turn sight distance" will be adequate for passenger cars, but may be inadequate for large trucks. The check on adequate sight distance is best done graphically on a sketch drawn to scale. Additional guidance can be found in Chapter Eight of the AASHO Policy on the Geometric Design of Rural Highways.

Two actions may be taken to increase the left turn sight distance: (1) the length of the vertical curve on the crossroad may be lengthened or (2) the location of the ramp terminal intersection with the crossroad may be shifted.

If it is not economically feasible to provide minimum sight distance, special approval must be obtained for designs less than standard.



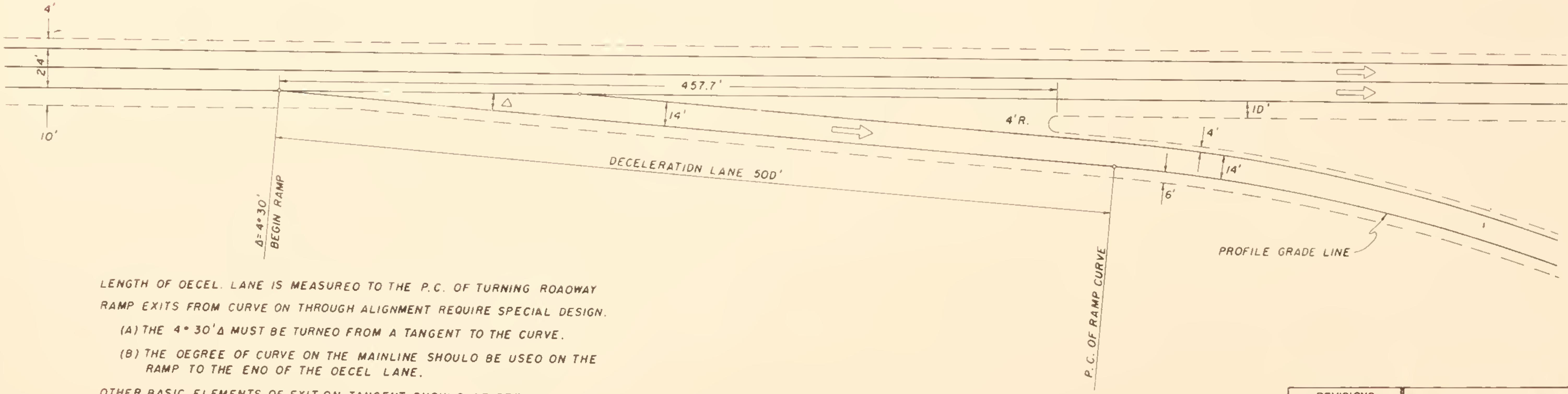
50:1 MERGING TAPER SHOULD NOT BE DECREASED FOR LOWER DESIGN SPEEDS.

TURNING ROADWAY & THROUGH TRAFFIC LANES SHOULD APPROACH SHOULDER AT APPROXIMATELY SAME ELEVATION.

SIGHT DISTANCE APPROACHING MERGING AREAS SHOULD NOT BE OBSCURED BY OTHER FACILITIES SUCH AS BRIDGES.

ACCELERATION LANE ONLY				
ADT	LT. SH. "A"	RAMP LANE "B"	RT. SH. "C"	TOTAL WIDTH
LESS THAN 100	2'	12'	4'	18'
100 TO 199	4'	12'	4'	20'
200 TO 300	4'	14'	4'	22'
MORE THAN 300	4'	14'	6'	24'

ACCELERATION LANE



LENGTH OF DECEL. LANE IS MEASURED TO THE P.C. OF TURNING ROADWAY

RAMP EXITS FROM CURVE ON THROUGH ALIGNMENT REQUIRE SPECIAL DESIGN.

(A) THE 4° 30' Δ MUST BE TURNED FROM A TANGENT TO THE CURVE.

(B) THE DEGREE OF CURVE ON THE MAINLINE SHOULD BE USED ON THE RAMP TO THE END OF THE DECEL LANE.

OTHER BASIC ELEMENTS OF EXIT ON TANGENT SHOULD BE RETAINED.

DECELERATION LANE

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ACCELERATION LANES
AND
DECELERATION LANES

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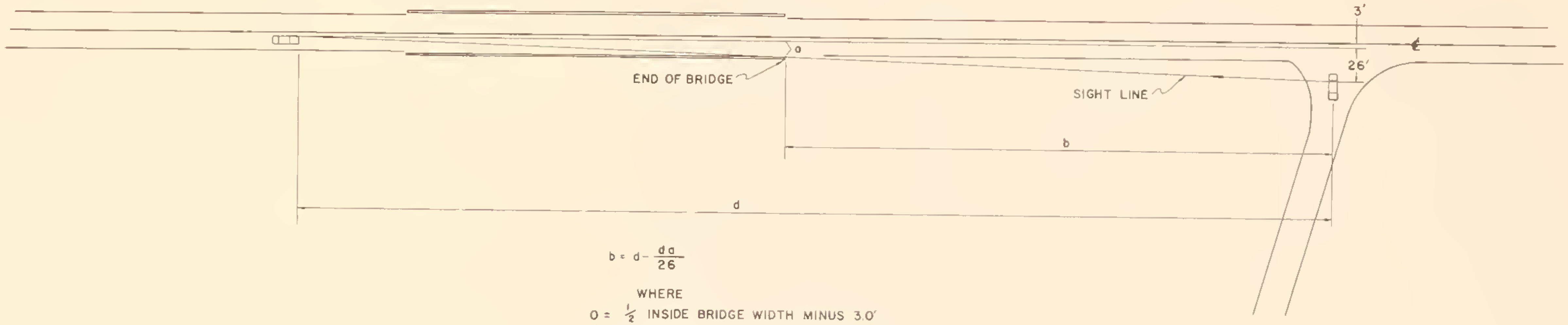
STANDARD SHEET NO. 801

SIGHT DISTANCE
AT RAMP TERMINALS

HORIZONAL

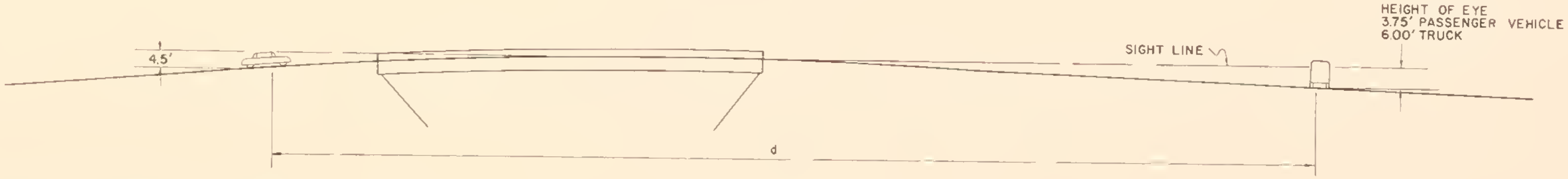


$$b = d - \frac{da}{26}$$

WHERE

a = ½ INSIDE BRIDGE WIDTH MINUS 3.0'
d = REQUIRED SIGHT DISTANCE IN FEET

VERTICAL



Crossroad Design Speed (MPH)	Required Sight Distance-Feet		
	Normal Conditions	Passenger Cars and Light Trucks Only	Industrial Areas Large Trucks
70	1,060	740	1,430
60	910	630	1,230
50	760	530	1,030
40	610	420	820
30	460	320	620

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SIGHT DISTANCE AT
RAMP TERMINALS

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STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 802

SURFACING

Chapter Nine

SURFACING

GENERAL CONSIDERATIONS

This chapter sets forth criteria and procedures to be followed in the design of highway surfacing.

For each project, basic decisions relative to surfacing design are formulated by the Surfacing Selection Committee, based on recommendations by the Surfacing Design Engineer. These decisions include:

- Type of finished surface
- Kinds of materials
- Thicknesses of the various courses.

Following review and approval by the Assistant State Highway Engineer - Engineering, and concurrence by the Federal Highway Administration, the project designer is advised of the recommendations.

TYPICAL SECTION GEOMETRICS

The recommendations for structural design of the surfacing must be applied to the standard typical section selected for each project. Surfacing thicknesses will be identified to the nearest 0.05 ft. The horizontal dimensions of the various surface courses must be computed for the purposes of:

- Computing surfacing quantities
- Staking in the field for construction

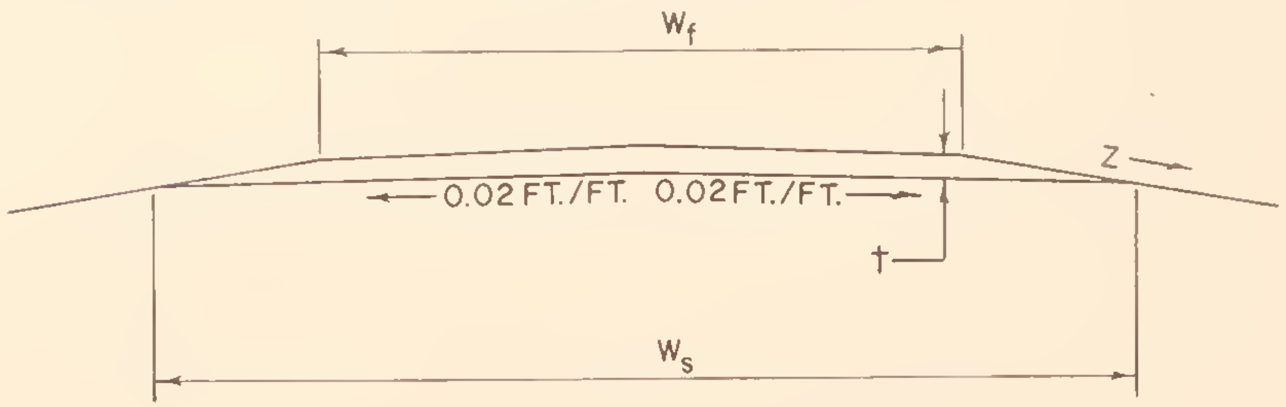
Symmetrical Sections

Most commonly used typical sections will be for 2-lane highways on tangent alignment with normal crown slopes. Dimensions of the subgrade width and intermediate surfacing courses will be symmetrical around the centerline.

The finished roadway width will be identified on the standard typical section. The first computation is to establish the width of subgrade using the following formula:

$$W_s = W_f + 2 \left(\frac{t\ Z}{1 - 0.02\ Z} \right)$$

where:
W_s = Width of subgrade
W_f = Width of finished grade
t = Total surfacing thickness at finished shoulder
Z = Side slope



For example, where W_f = 26.0
t = 1.80'
Z = 6:1

$$W_s = 26.0 + 2 \left(\frac{1.80 \times 6}{1 - 0.02\ Z} \right)$$

$$= 26.0 + 24.54 = 50.54$$

$$= 50.0$$ (round to nearest even foot)

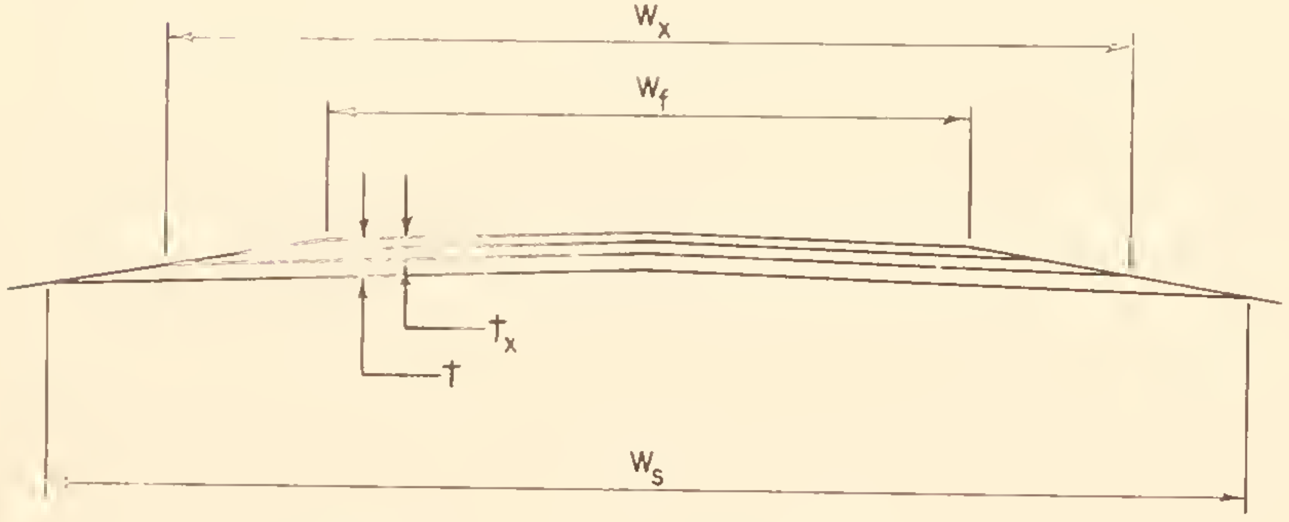
Because of the rounding process, the side slope through the surfacing courses will not be exactly 6:1, but the difference is negligible and the even dimension facilitates staking of the subgrade.

The second computation is to establish the width of the intermediate surfacing courses. Each horizontal dimension shall be computed proportionately to the thickness.

For example, the width at the top of any surfacing course may be determined by the following formula:

$$W_x = W_f + \frac{t_x}{t} \left(W_s - W_f \right)$$

where: W_x = Top width of intermediate surfacing course
W_f = Width of finished grade
W_s = Width of subgrade
t = Total surfacing thickness at finished shoulder
t_x = Accumulative thickness of courses above W_x



All computed intermediate widths (W_x) will be rounded to the nearest 0.1 feet.

Unsymmetrical Sections

When sections are not symmetrical about the centerline, the widths to the left and right of centerline must be computed and recorded separately. This situation exists with all superelevated sections and with divided highways where the inside and outside shoulders are different widths.

To compute subgrade widths for superelevated sections, the following formulae will be used:

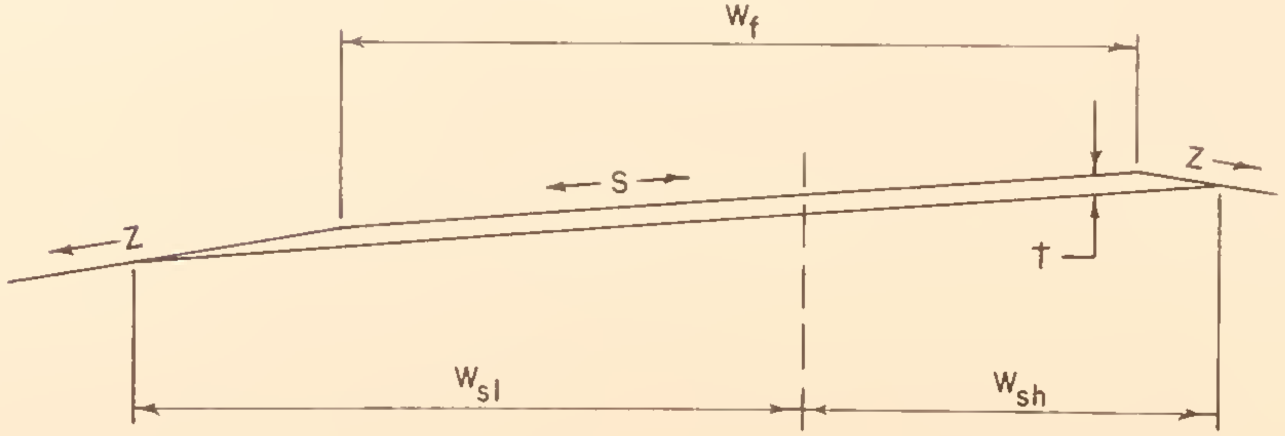
Low Side

$$W_{sl} = \frac{W_f}{2} + \frac{t\,Z}{1 - SZ}$$

High Side

$$W_{sh} = \frac{W_f}{2} + \frac{t\,Z}{1 + SZ}$$

where: W_{sl} = Width from centerline to edge of subgrade on low side of superelevation
W_{sh} = Width from centerline to edge of subgrade on high side of superelevation
W_f = Width of finished grade
t = Total thickness of surfacing
S = Slope of superelevation (ft./ft.)
Z = Side slope



The computed values for W_{sl} and W_{sh} will each be rounded to the nearest foot of width.

For divided highways on tangent or curve sections, the subgrade widths left and right of centerline are computed as follows:

TANGENT

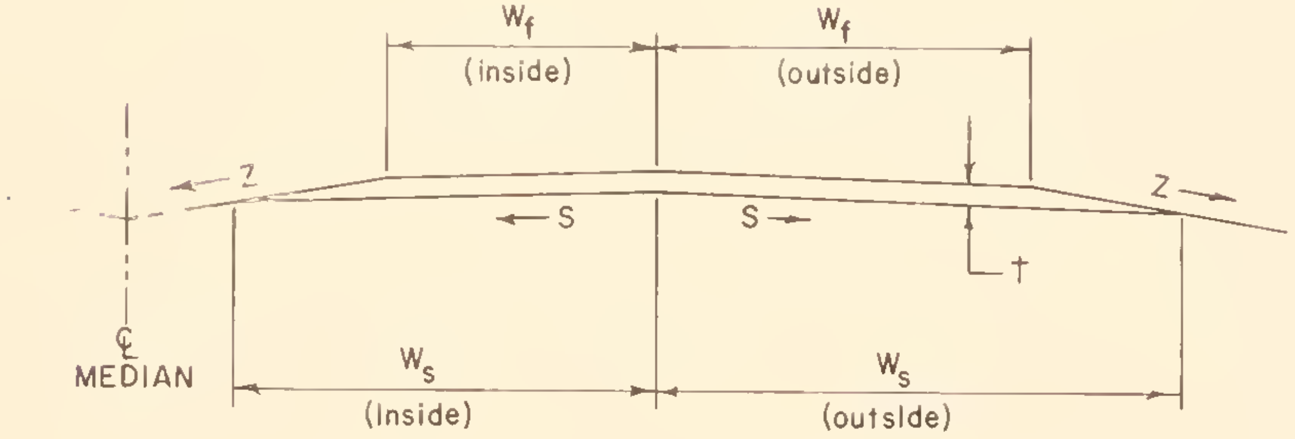
$$W_s\text{ (inside)} = W_f\text{ (inside)} + \frac{tZ}{1 - 0.02Z}$$

$$W_s\text{(outside)} = W_f\text{(outside)} + \frac{tZ}{1 - 0.02Z}$$

CURVE

$$W_s\text{ (inside)} = W_f\text{ (inside)} + \frac{tZ}{1 + SZ}$$

$$W_s\text{ (outside)} = W_f\text{ (outside)} + \frac{tZ}{1 + SZ}$$



The computed W_s (outside) always will be rounded to the nearest foot of width.

The computed W_s (inside) always will be rounded to the nearest 0.1 foot of width when the median is uniformly controlled.

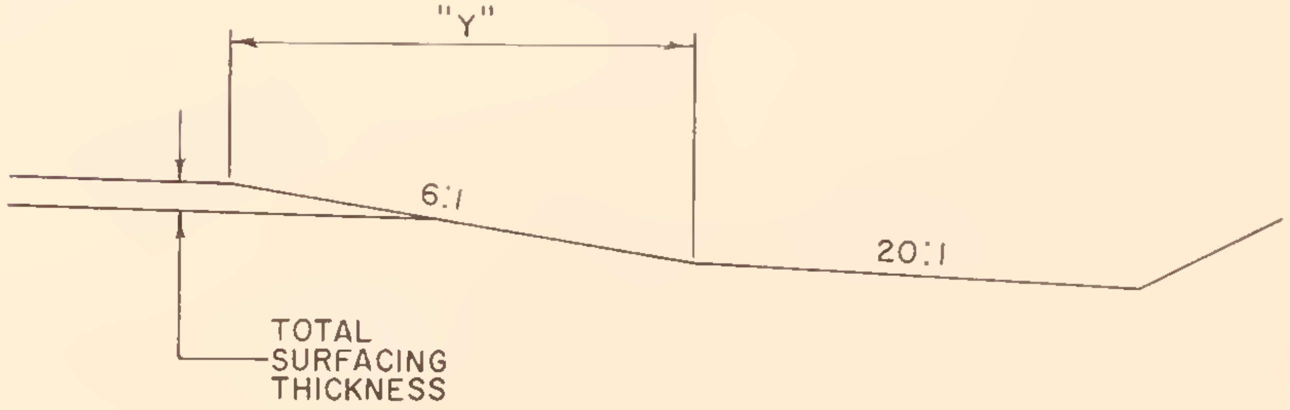
In the case of divided independent roadways, both W_s (outside) and W_s (inside) will be rounded to the nearest foot.

The widths of intermediate surfacing courses for unsymmetrical sections will be computed in the same manner as for symmetrical sections (proportionately to the thicknesses), except that widths will be computed and recorded separately for each side of the centerline.

Sideslope Distance

The sideslope distance from the outside edge of the shoulder to the point at which the slope breaks to a 20:1 ditch slope is variable depending on the total surfacing thickness. This distance must be identified on the typical section sheet after the surfacing thickness is established. Criteria for this distance are shown in the table below.

Surface Thickness (at finished shoulder)	Distance "Y"
0' - 1.35'	15'
1.40' - 1.50'	16'
1.55' - 1.65'	17'
1.70' - 1.80'	18'
1.85' - 1.95'	19'
2.00' - 2.10'	20'
2.15' - 2.25'	21'
2.30' - 2.40'	22'
2.45' - 2.55'	23'
2.60' - 2.70'	24'
2.75' and over	Special Design



For the initial design, the sideslope distance on high fill sections will provide at least 15.0 feet of 6:1 slope before breaking to a steeper slope. For extremely long, high fills, the economics of reducing the 15.0 feet safety slope to the subgrade shoulder should be considered at the time of the preliminary P.I.H. inspection.

COMPUTING SURFACING QUANTITIES

For each typical section, computations will be made to determine the required quantities per station of each type of surfacing material. Subsequently these values will be used to compute total surfacing quantities for the entire project. To assure consistency and uniformity, the computation steps described below must be followed.

Gravel Quantities

1. Compute the cross section end area for each course by multiplying the thickness (nearest 0.05 feet) by the average of the top and bottom widths. End areas should be rounded and recorded to the nearest 0.1 square foot .

2. Compute the cubic yards per station with this formula:

$$\text{C.Y./Sta.} = \frac{\text{End Area (sq.ft.)} \times 100}{27}$$

   Round the answer to the nearest 0.1 cubic yard.

3. Compute tons per station. Unless other wise directed, use 3700 pounds per cubic yard for conversion.

$$\text{Tons/Sta.} = \text{C.Y./Sta} \times \frac{3700}{2000} = \text{C.Y./Sta.} \times 1.85$$

   Round the answer to the nearest 0.1 ton. Specific unit weights for gravel may be given for individual projects.

4. Compute tons per mile by multiplying Tons/Sta. by 52.8. Round the answer to the nearest 0.1 ton.

Rounding should be accomplished as directed for each step in sequence before proceeding to the next step. Values should be recorded on the typical section sheet as illustrated in the model sheet in Chapter Fifteen.

Plant Mix Quantities

1. Compute cross section end areas. If the plant mix course is of uniform thickness, the procedure is the same as for other gravel courses. If cross slopes are steepened, special computation must be made to allow for variable thickness. Round the answers to the nearest 0.1 square foot.

2. Compute cubic yards per station in the same manner as for gravel quantities.

3. Compute average surface area in square yards per station.

$$\text{S.Y./Sta.} = \text{C.Y./Sta.} \div \frac{\text{Thickness (ft.)}}{3}$$

   Round the answer to the nearest 0.1 square yard.
   It should be noted that in the case of tapered shoulders with nonuniform thickness, the value for S.Y./sta. represents an equivalent area of uniform thickness rather than an actual measureable area.

4. Compute tons per station on the basis of a weight of 128.5 pounds per 0.1 foot of thickness per square yard of area.

$$\text{Tons/Sta.} = \frac{128.5}{2000} \times \frac{\text{Thickness (ft.)}}{0.1} \times \text{S.Y./Sta.}$$

   Round the answer to the nearest 0.1 ton.
   This value includes the weight of both gravel and bituminous materials.

5. Compute tons per mile.

$$\text{Tons/Mile} = \text{Tons/Sta.} \times 52.8$$

   Round the answer to the nearest 0.1 ton.

All rounding of computations should be performed in sequence by steps as directed.

Bituminous Material Quantities

For estimating purposes, all bituminous material is assumed to weigh 8.5 pounds per gallon.

Plant Mix Oil -- Quantities to be estimated at 6.5 percent of the computed weight of plant mix and recorded to the nearest 0.1 ton per station and per mile.

For plant mix bituminous base, the asphalt quantity will be computed as 5.0 percent of the total weight.

Prime Oil -- Prime oil will be applied at the rate of 0.3 gallon per square yard of surface area of top course gravel. Quantities will be recorded as tons/sta. and tons/mile. For computation purposes, the rate of application should be converted to 0.001275 tons/sq. yd. Round the answer to the nearest 0.1 ton.

Tack Oil -- Tack oil will be applied at the rate of 0.1 gallon per square yard between lifts of plant mix material and between plant mix surfacing and bituminous-stabilized base courses. The square yards of surface area computed for prime oil should be used also for estimating tack oil quantities -- even though the area is not precisely correct. Quantities should be computed and recorded in gallons per station and gallons per mile -- rounded to the nearest 0.1 gallon. Do not convert quantities of tack oil to tons.

Approach Surfacing

On bituminous-surfaced projects, all approaches will be surfaced to the right-of-way line unless other wise directed. Occasionally used approaches which warrant gravel surfaces only will be identified at the time of plan-in-hand inspection. Design criteria for approaches are shown on Standard Drawing No. 103.

Standard Sheet No. 901 shows typical approach surfacing and a table of surfacing quantities for various lengths of approaches. The values in the table should be used for estimating purposes only.

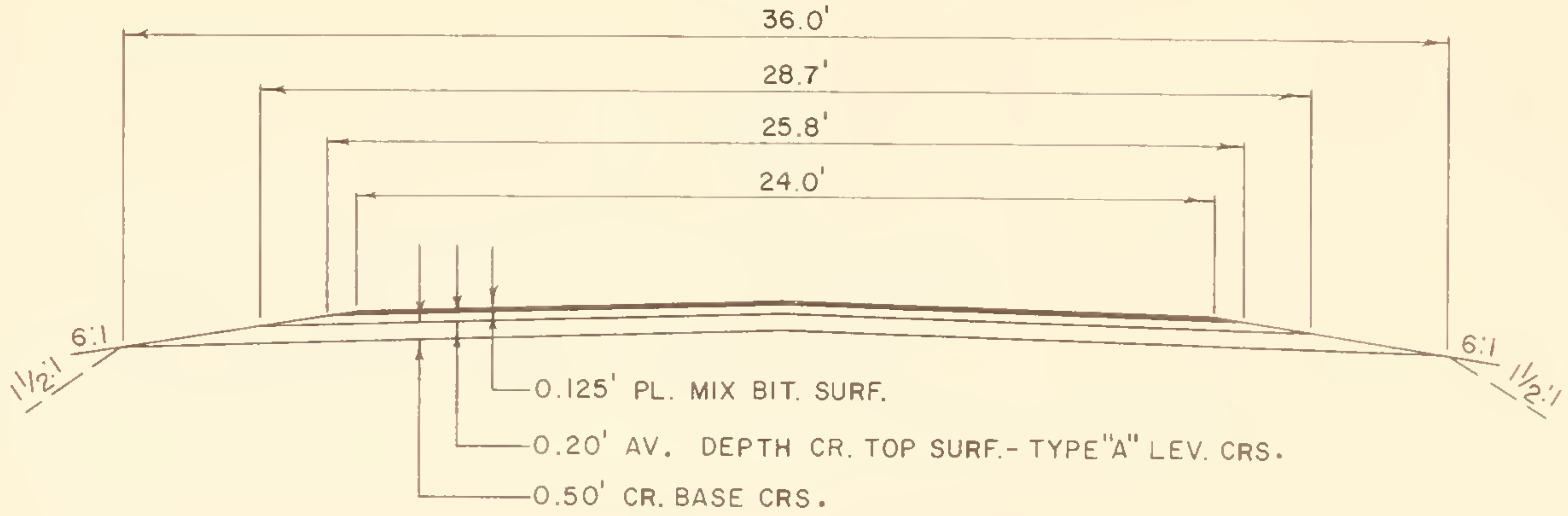
On secondary roads with plant mix base as stage construction projects, approach quantities should be estimated in accordance with Standard Sheet No. 902. The quantities shown in the table for various length approaches should be used for estimating purposes only. For future surfacing, a 12 ft. tapered section will be made from the finished shoulder to the road approach.

Summary of Quantities

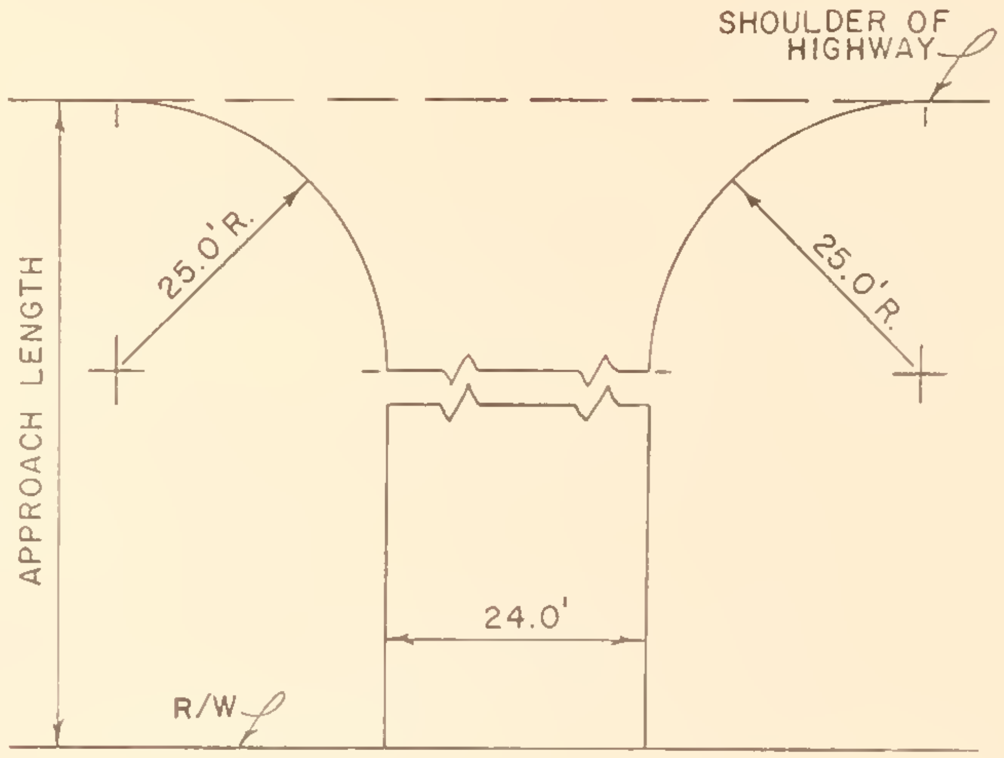
Total quantities of surfacing materials will be computed and summarized in the format shown in Chapter Fifteen. Computed quantities should be rounded as follows:

- Gravel and plant mix -- nearest ton
- Tack coat -- nearest gallon
- All other bituminous material -- nearest 0.1 ton
- Sand surfacing and pit run material -- nearest C.Y.

TYPICAL SECTION


36.0'
28.7'
25.8'
24.0'
6:1
1½:1
6:1
1½:1
0.125' PL. MIX BIT. SURF.
0.20' AV. DEPTH CR. TOP SURF.- TYPE "A" LEV. CRS.
0.50' CR. BASE CRS.

PLAN



Quantities Per Approach (Incl. Wyes - 25' Radius)								
App. Length (Ft.)	Tons (Grav. Est. @ 3700 lbs.)					Tons Bit. Mat'l.		
	Cov. Mat'l.	Pl. Mix*	Cr. Top	Cr. Base		Pl. Mix (6½%)	** Prime	** Seal
25	1	8	14	40		0.5	0.1	0.1
30	1	9	16	45		0.6	0.2	0.2
35	2	10	17	51		0.7	0.2	0.2
40	2	11	19	57		0.7	0.2	0.2
45	2	13	21	62		0.8	0.2	0.2
50	2	14	23	68		0.9	0.2	0.2
55	2	15	24	73		1.0	0.2	0.2
60	3	16	26	79		1.0	0.3	0.3
65	3	17	29	85		1.1	0.3	0.3
70	3	18	31	90		1.2	0.3	0.3
75	3	19	33	95		1.2	0.3	0.3
80	3	20	34	101		1.3	0.3	0.3
85	3	21	36	107		1.4	0.4	0.4
90	4	23	38	112		1.5	0.4	0.4
95	4	24	40	117		1.5	0.4	0.4
100	4	25	41	124		1.6	0.4	0.4

*Incl. Weight of Pl. Mix Mat'l. Comp. Wt. Pl. Mix 128.5 lbs. per sq. yd. per 0.10' thickness.
**Based on 0.30 gallons per square yard.

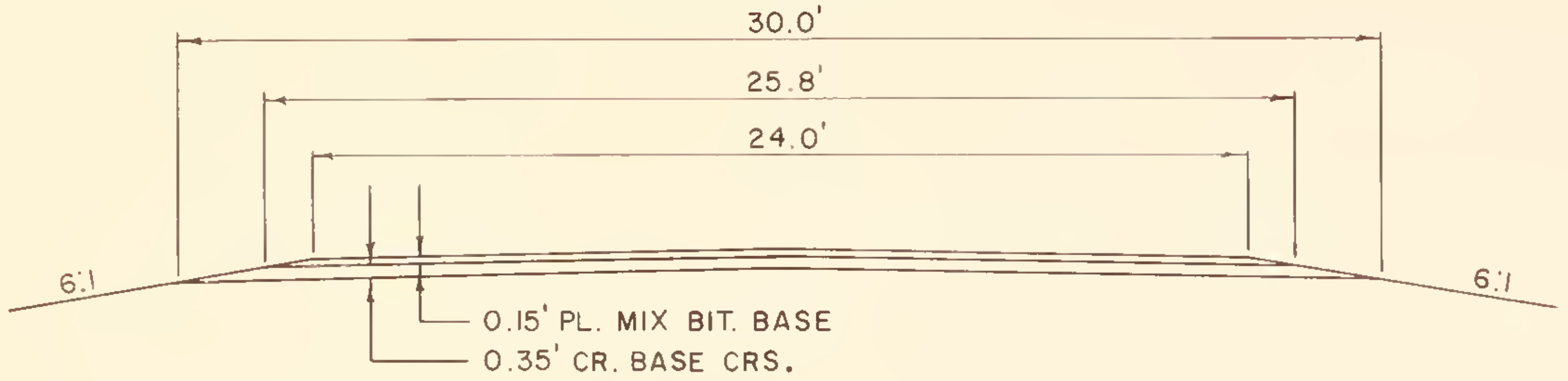
REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

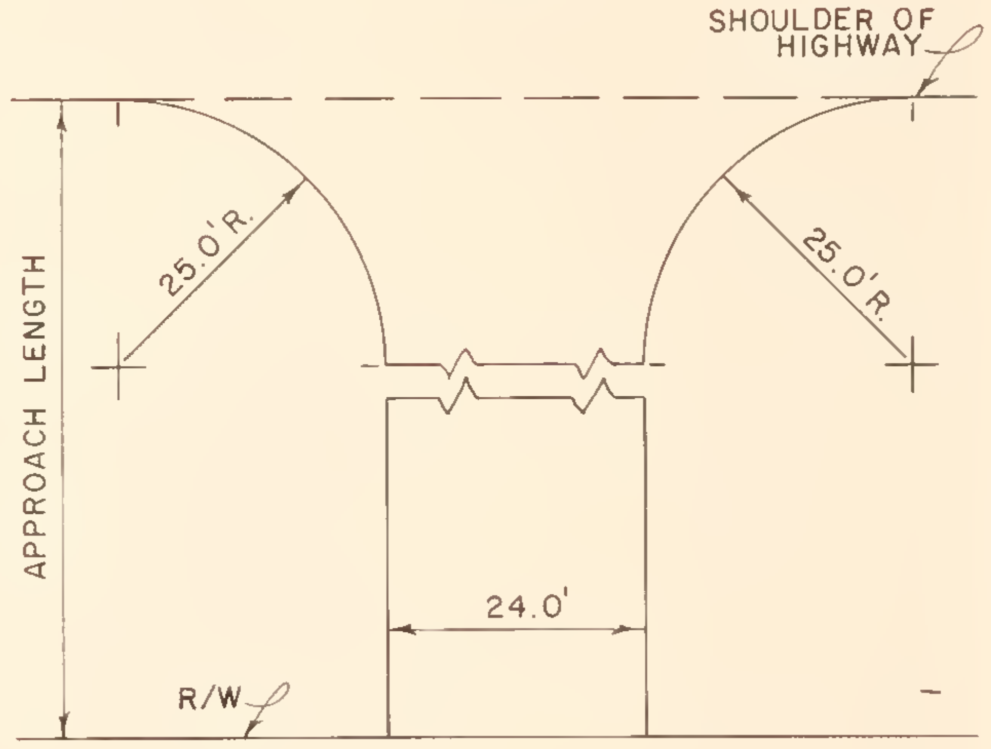
ESTIMATED QUANTITIES FOR APPROACH SURFACING

APPROVED
STATE HIGHWAY ENGINEER
STANDARD SHEET NO. 901

TYPICAL SECTION



PLAN



Quantities Per Approach (Incl. Wyes - 25.0 Radius)									
	Tons								
App. Length (Ft.)	Cover Mat'l. (25 lbs.)	Pl. Mix Bit. Base	CRUSHED BASE COURSE				Pl. Mix Bit. Mat'l. (5%)	Prime *	Seal *
						3700 lbs.			
25	1	9				23	0.5	0.1	0.1
30	1	10				26	0.5	0.1	0.1
35	2	12				30	0.6	0.2	0.2
40	2	13				33	0.7	0.2	0.2
45	2	14				36	0.7	0.2	0.2
50	2	16				39	0.8	0.2	0.2
55	2	17				42	0.8	0.2	0.2
60	2	19				45	0.9	0.3	0.3
65	3	21				49	1.0	0.3	0.3
70	3	22				52	1.1	0.3	0.3
75	3	23				55	1.2	0.3	0.3
80	3	24				58	1.2	0.3	0.3
85	3	26				61	1.3	0.3	0.3
90	4	27				64	1.4	0.4	0.4
95	4	28				68	1.4	0.4	0.4
100	4	30				71	1.5	0.4	0.4

*Based on 0.30 gallons per square yard.
Plant Mix Bit. Base = 128.5 lbs. per sq. yd. per 0.10' thickness.

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

ESTIMATED QUANTITIES
FOR STAGE CONSTRUCTION
APPROACH SURFACING

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 902

ROADSIDE DEVELOPMENT

Chapter Ten

ROADSIDE DEVELOPMENT

GENERAL CONSIDERATIONS

This chapter presents criteria for the design of roadside development items, including rest areas, historical marker turnouts, topsoiling and seeding.

REST AREAS

General locations and criteria for rest areas are established during the planning phase and documented in the Planning Report.

Preliminary Layout

Based on the criteria set forth in the Planning Report, a preliminary layout will be prepared for each rest area. The preliminary layout should define the location and approximate geometrics of the rest area.

The preliminary layout does not require refined details -- stationing may be scaled, grades to the nearest percent, traverses need not be closed. The basic purpose is to clearly illustrate the layout in relation to existing terrain so as to verify that the proposed design is both feasible and economical.

After preliminary layouts are developed so that building locations can be approximately established, water exploration and percolation tests will be requested.

Layout Review

Prior to the preliminary plan-in-hand (P.I.H.) inspection, the preliminary layouts will be developed by the designer in cooperation with the Traffic and Environmental Units. The Federal Highway Administration will be consulted in instances where their views are desired with relation to specific questions.

At the time of the preliminary P.I.H. inspection, the layouts are further reviewed in the field, particularly with regard to alignments and grades.

Detailed Design

Following preliminary P.I.H. approval, the detailed design of the rest area will be initiated. The detailed design for the general contract will include:

- Precise identification of ramp and rest area alignments and curvatures with computed ties and traverse closures.
- Precise identification of elevations and grades to the nearest 0.01 feet.
- Identification of proposed sidewalks, curbs and utility lines and wells necessary to serve the rest area.

The detailed design for the general contract should be coordinated with the Environmental Unit. The Environmental Unit will provide preliminary layouts and related information for landscaping, building, recreational installations and other facilities.

Design Criteria

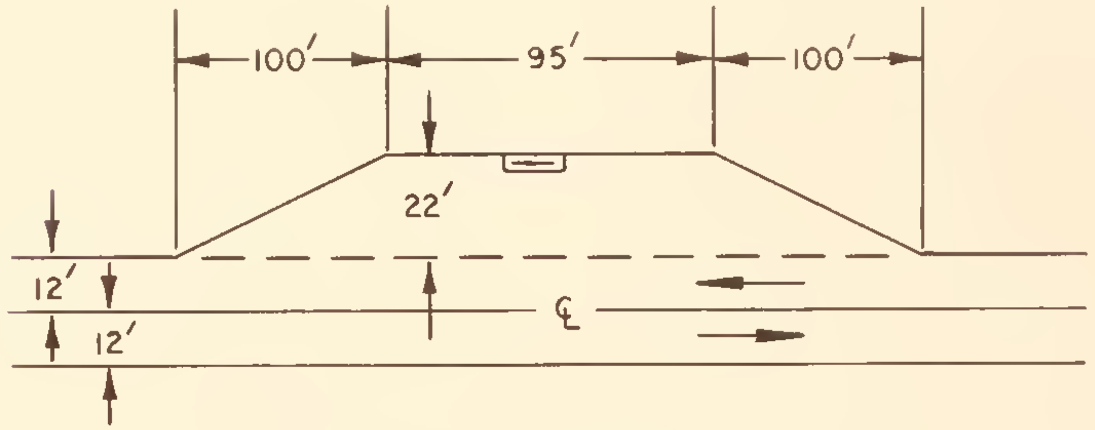
The following criteria will apply to the design of rest areas:

- Ramp Width -- All ramps will be 24 feet wide.
- Acceleration and Deceleration Lanes -- Illustrated examples and detailed design criteria for acceleration and deceleration lanes are shown on Standard Sheet No. 801 in Chapter Eight.
- Parking Spaces -- Criteria for the numbers and sizes of parking spaces are shown on Standard Sheet No. 1001. The required numbers of parking spaces are based on the design year ADT. A typical layout of a parking area shows standard size parking spaces for cars and trucks.
- Preservation of Natural Environment -- Designers should be guided by the Department's policy to preserve the natural environment in rest areas. Heavy cuts and fills should be avoided. Where practicable, grades should be splined to fit the natural terrain, and curbs should be used to avoid unsightly ditch sections.

HISTORICAL MARKERS

When historical markers are to be erected along the roadside, the markers should be economically located where there will be a minimum of conflict between through traffic and traffic at the marker site. Specific criteria are presented below.

On Interstate highways, historical markers should be placed at rest areas or on local roads near interchanges. On other highways, sites for historical markers may be designed similar to the example below:



HISTORICAL MARKER TURNOUT
ON 2-LANE HIGHWAY

Details for the construction and erection of historical markers may be obtained from the Environmental Unit.

I. Traffic data

A - 20 year ADT
B - Peak hour directional traffic = A x K x D
where: K = ratio of design hourly volume to ADT (generally about 0.135)
D = directional distribution of design hourly volume (generally about 60%
C - Vehicles stopping, peak hour

The percentage of vehicles stopping in rest areas varies from about 5 percent to about 13 percent, depending upon location. For example,

1) Near commercial or recreational facilities, C = B x 0.5
2) Typical rural area, C = B x 0.09
3) In an isolated area, with no nearby commercial or recreational facilities, C = B x 0.13

II. Parking requirements

M = Total parking spaces = C x 0.5
N = Car parking spaces = M x 0.5
A lower factor than 0.5 may be used if truck traffic in high
O = Truck parking spaces = M - N

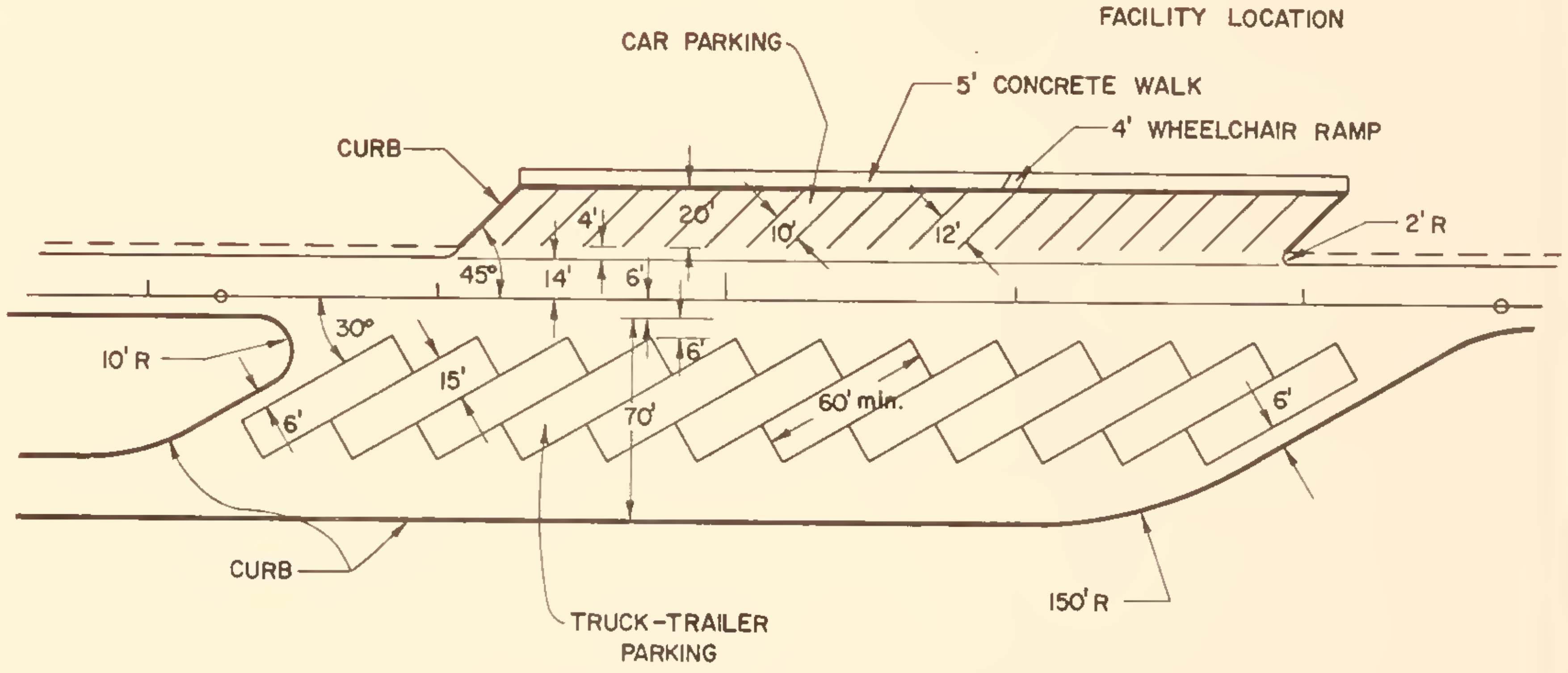
III. Confort facilities

P = Persons/hour using comfort facilities = C x 2.25
The factor 2.25 is derived by multiplying the average vehicle Occupancy (3.0) by the ratio of persons using comfort facilities (0.75)
Q = Number of persons using men's facility = P x 0.5
R = Number of persons using women's facility = P x 0.5

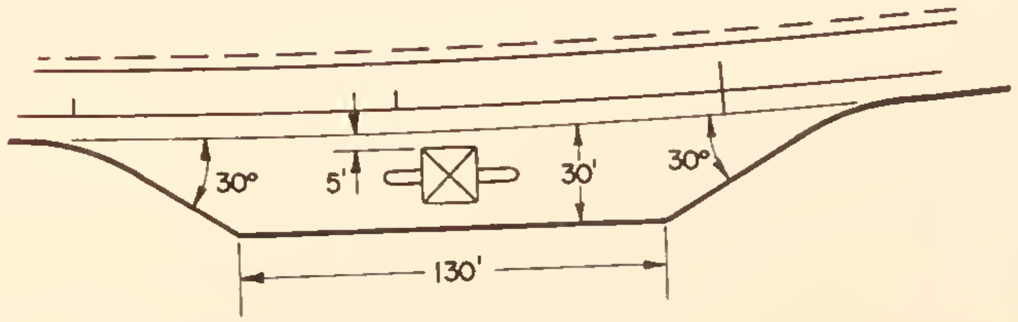
The required facilities may be determined by entering the value for persons/hour into the following table.

Persons/hours using rest room during design hours (Q)	Number of facilities - men's room				
	Urinals	Toilets	Wash basins	Hand dryers Paper towels or	Air dryers
0-105	2	2	2	2	2
105-225	3	3	4	3	4
225-315	4	4	5	4	6

Persons/hours using rest room during design hours (R)	Number of facilities - women's room			
	Toilets	Wash basins	Hand dryers Paper towels or	Air dryers
0-105	4	3	2	2
105-225	6	4	3	4
225-315	9	6	4	6



TYPICAL PARKING LAYOUT



TRAILER DISPOSAL LAYOUT

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MONTANA
DEPARTMENT OF HIGHWAYS

REST AREA
PARKING

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO. 1001

TOPSOIL

Four inches of topsoil (loose depth) will be provided where sufficient topsoil is available. Topsoil will be required on slopes 2:1 and flatter. Some 1½:1 slopes will be topsoiled, depending on individual conditions.

All secondary projects will be topsoiled unless they are being built out of topsoil or topsoil is not available on the project.

The following procedure will be used to compute topsoil quantities and indicate those quantities on the plans:

1. Balance the earthwork for the project without regard to topsoil.

2. Compute the cubic yards of topsoil, based on a 4-inch loose depth on all slopes 2:1 and flatter. For consistency in the results of topsoil computations, use the following formula:

   Cubic yards of topsoil = X Z
   Where X = Average width of area to be topsoiled, in feet
   Z = Constant for the length of the area to be topsoiled. The constants to be used for various lengths are as follows:

Length of Area To Be Topsoiled, in Stations	Constant (Z)
1	1.23333
2	2.46667
3	3.70000
4	4.93333
5	6.16667
6	7.40000
7	8.63333
8	9.86667
9	11.10000
10	12.33333

3. Indicate the quantities in the topsoil summary. A model topsoil summary is shown in Chapter Fifteen.

4. Enter the topsoil quantity plus 20 percent (shrinkage) as "Topsoil Replacement" in the Additional Excavation Summary.

SEEDING

For each project requiring seeding, designers will prepare the following items:

- Seeding summary -- similar to the model summary shown in Chapter Fifteen.
- Seeding notes -- setting forth the types and rates of seed, fertilizer and mulch. Typical seeding notes are shown on the model notes sheet in Chapter Fifteen.

Seeding summaries and seeding notes will be prepared according to the criteria presented below.

Seeding Recommendations

Seeding recommendations from the Environmental Unit will define the types and rates (units per acre) of seed, fertilizer and mulch to be used. Different seeding rates will be specified for areas on slopes 3:1 and flatter, areas on slopes steeper than 3:1 and for other areas as defined in the seeding recommendations. To compute quantities for the seeding summary, designers must first determine the acreages of the various areas to be seeded.

Areas to be Seeded

The areas to be seeded include all areas along the roadway, except surfaced areas, areas steeper than 1½:1 and areas where grass cannot be expected because of rock or other unusual conditions. The cross sections will be used as the bases for computing acreages to be seeded.

Quantity Estimates

The following guidelines should be used to estimate quantities for the seeding summary:

- Show separate acreages and quantities for areas on slopes 3:1 or flatter, areas on slopes steeper than 3:1 and for other areas defined in the seeding recommendations.
- Separately identify the acreages and quantities for the mainline and for each interchange, rest area, frontage road, weigh station and other item not on the mainline.
- Increase seed quantities by 10 percent for contingency purposes.

RIGHT-OF-WAY

Chapter Eleven

RIGHT-OF-WAY

GENERAL CONSIDERATIONS

Right-of-way plans must be prepared in ways to clearly define the land needed for highway construction. Development of right-of-way plans and the data shown on them requires the cooperative effort of many persons, including:

- Field survey crews
- Abstracters
- Highway designers
- Right-of-way designers
- Right-of-way agents

This chapter is directed principally to the right-of-way designer and sets forth policies and procedures for his guidance in coordinating the preparation of right-of-way plans.

A typical set of right-of-way plans will consist of a title sheet and a series of plan sheets showing alignment, basic topography, township and range lines, property lines, property owners and a description of the required land.

The base maps for this information should be prepared as soon as possible -- even before the specific right-of-way requirements are known. Tracings prepared by the highway designer for construction plans can be readily adapted for right-of-way plans.

PLAN SHEETS

The sheets showing alignment of the project are produced from photographic negatives of the plan portion of plan-profile sheets after tracings have been completed by the highway designer. Information not required on the right-of-way plans should be blacked out on the negative before reproduction.

Items that may be significant during negotiations with the owners should be shown on the right-of-way plans-- items such as shelter belts, fruit trees, ornamental bushes or trees, hedges, sidewalks, planters, permanent yard appliances or ornaments, paved driveways and underground cisterns or septic tanks. All buildings should always be shown.

Additional information must be added to the sheets. This will be discussed later.

Plan sheets should be prepared to the following scales:

Urban Areas	1" = 50'
Rural Areas:	1" = 100'

Care should be taken in the photographic reproduction process to assure retention of accurate scales.

A typical completed right-of-way plan sheet is shown at the end of this chapter.

Section Ties and Land Lines

When preparing property descriptions for land acquisition, it is essential that there be accurate ties between the highway alignment and the documented land lines. Such ties normally are included in the field survey and recorded on the plan sheets. However, because of the legal significance of this information, it should be carefully checked by the right-of-way designer. Missing information should be identified, and additional land lines should be drawn as appropriate.

Existing Right-of-Way

Where the proposed alignment is fairly close to the present traveled way (P.T.W.) or where it intersects with other state highways, the right-of-way lines defining previously acquired land should be drawn as a light solid line. This information is available from previous right-of-way maps and deeds to land purchased.

The lines should be labeled "Existing R/W" if there are deeds to show the land was acquired, or labeled "P.T.W." if there are no deeds.

Current Ownership

Descriptions of current property ownerships are obtained from "title memos" which are secured from abstracters in the area of the project.

A wide-band ownership map of the total contiguous land is prepared in the field office. The information on this map is transferred to the map centrally located on the title sheet or the ownership sheet.

On the regular right-of-way plan sheets, evenly spaced dots are used to show the extent of each ownership. At places where ownership changes, centerline stationing should be shown.

Owners' names, parcel numbers and area figures are shown in the ownership box in the upper left corner of each plan sheet. The index on the title sheet should show the owners' names, the parcel numbers and the sheet numbers where the parcels may be found.

TITLE SHEET

The title sheet for the construction plans also may be converted to a title sheet for the right-of-way plans by photographic reproduction. Unnecessary information should be blacked out on the negative. Typical right-of-way symbols and a sheet index showing parcel numbers and ownerships should be added.

If the location map is congested with many property owners, it should be placed on a separate sheet.

A typical completed right-of-way title sheet is shown at the end of this chapter.

OWNERSHIP SHEET

A wide band map clearly defining the property ownerships and individual parcels for the entire project is required. If the project is long or the ownerships are small and congested, the location map on the title sheet will not be adequate for this purpose.

A separate ownership location map should be prepared and inserted in the right-of-way plans immediately following the title sheet.

An example ownership location map is shown at the end of this chapter.

All of the actions described so far (except for assigning parcel numbers and determining right-of-way areas) can be completed before highway design is completed and actual construction limits have been established.

It is highly desirable that as much ownership information as possible be on the right-of-way plans at the time of final plan-in-hand inspection. At an early stage of development, brown lines of the right-of-way plans should be sent to Bureau of Right-of-Way to initiate title searches and wide-band ownership maps.

RIGHT-OF-WAY DESIGN CRITERIA

This section sets forth policies and criteria to guide the right-of-way designer in establishing and documenting right-of-way requirements.

Construction Limits

The principal guide for design of right-of-way is the identification of actual construction limits established during the highway design process.

When highway design has progressed to the point that construction limits can be identified with a reasonable degree of certainty, the right-of-way plan sheet linens should be given to the highway designer responsible for the project. Using computer runs or templated cross sections, the highway designer should document the construction limits on the right-of-way linens (in pencil) using a light solid line for top of cut and a light dashed line for toe of fill. The area of "slope rounding" should be included as a part of the construction limits.

Right-of-Way Widths

Obviously the right-of-way must be wide enough to accommodate the identified construction limits. Additional right-of-way width should be designed to provide a 20' minimum distance from the construction limits to the right-of-way line. Deviations from these criteria may be considered in the case of extremely high right-of-way costs.

The following desirable minimum right-of-way widths have been established as general criteria to be followed when high right-of-way cost is not a significant controlling factor:

- Interstate

  No frontage roads - 80 feet minimum from centerline of nearest main roadway to right-of-way line

  Frontage roads or ramp roads - 60 feet minimum from center of nearest roadway to right-of-way line

- Primary

  80 feet from centerline of nearest roadway to right-of-way line

- Secondary

  60 feet from centerline of nearest roadway to right-of-way line

- Urban Sections

  No set rules can be established governing right-of-way widths in urban areas. Sound judgment must be used to obtain a logical balance between right-of-way costs and widths. In general, border widths of 8 to 20 feet are desirable.

Right-of-Way Breaks

Try to design right-of-way lines with as few breaks and changes of width as possible. An unduly large number of breaks complicates the writing of right-of-way descriptions.

The following general criteria should apply:

- A right-of-way width parallel to the centerline should be maintained uniformly for at least 250 feet.
- A right-of-way width should not be changed for less than 10 feet (60 to 70 feet; not 60 to 65 feet).
- Except for changes at property lines or extremely large changes (25 feet), changes in right-of-way width should be accomplished with a taper of 4:1.
- Where widths change between adjacent property owners, the breaks should follow the property line.
- Where widths change close to P.C.'s or P.T.'s, try to make the breaks coincide with the curve points.
- Where width changes are required both left and right, try to make the break points coincide at the same stationing.
- Take the ownership boundaries into consideration. Sometimes it is advisable to run the right-of-way along the property line, either to avoid leaving a narrow strip of property or to avoid negotiating with another owner.

Beginning or Ending of Project

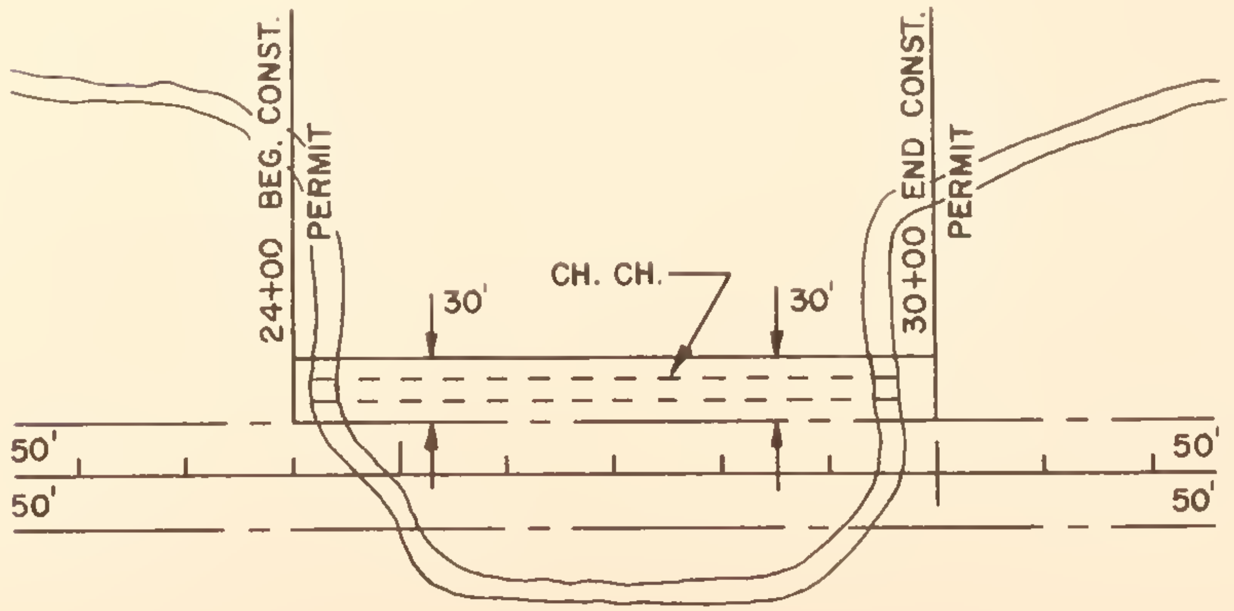
When right-of-way is designed at the beginning and ending of a project, and those points are within the limits of an individual ownership, consideration should be given to acquiring right-of-way through the ownership for future connecting projects so that the owner will not have to be contacted again.

Construction Permits and Easements

Under certain conditions it is not necessary to obtain permanent possession of land on which construction work is to be performed. Instead, a construction permit should be obtained.

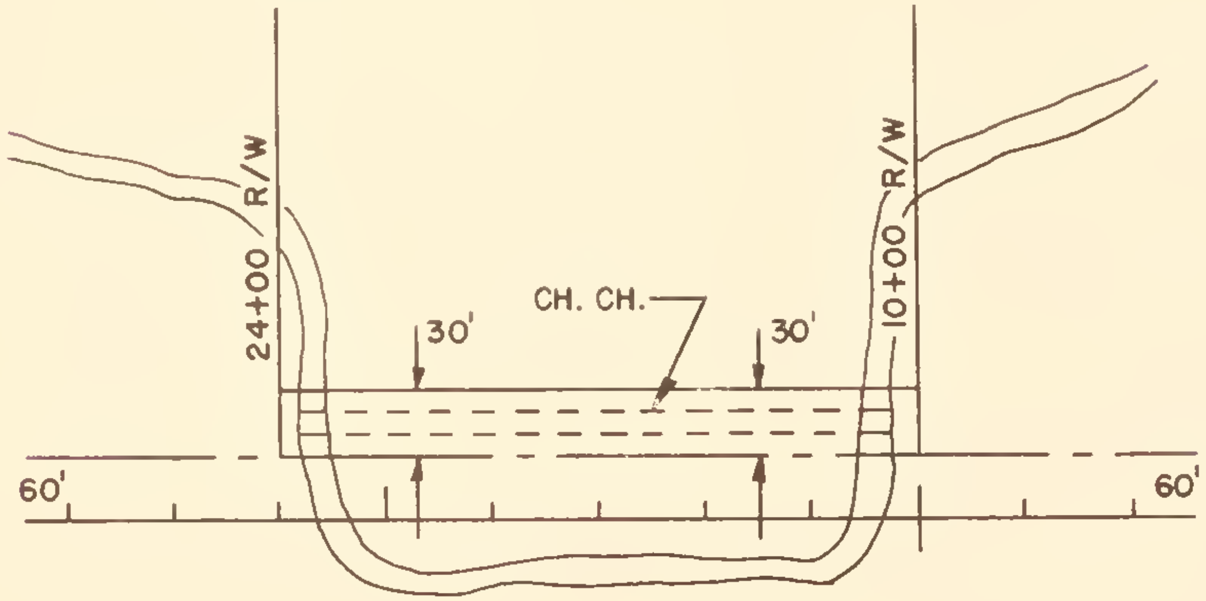
The following general criteria should apply:

- Private irrigation ditches should be designed outside the right-of-way. A construction permit or a construction easement should be obtained.

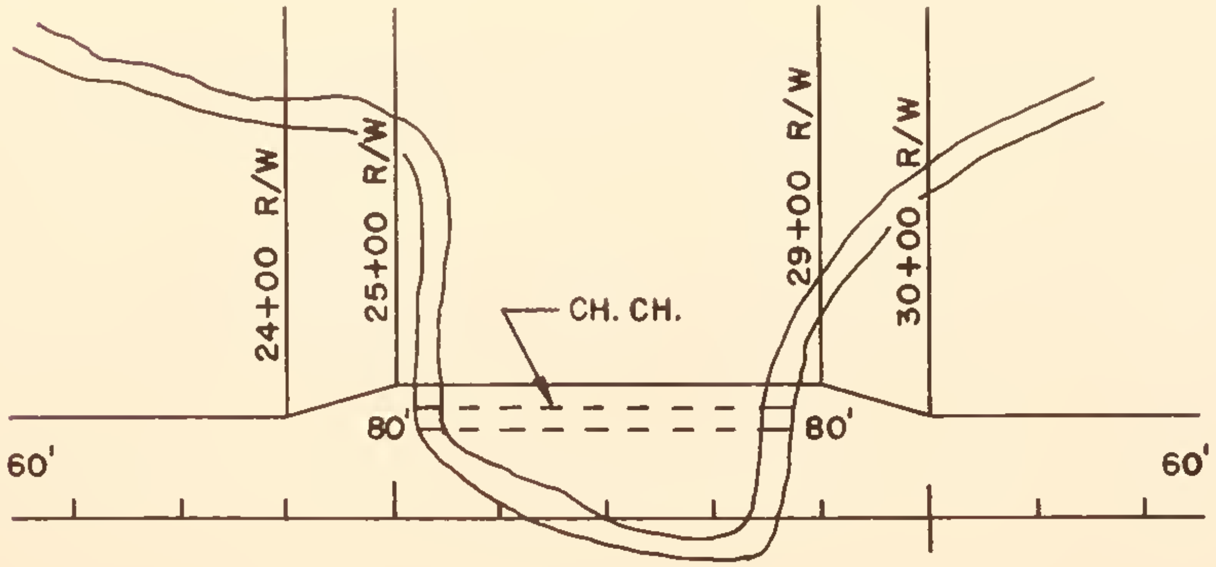


Construction Permits and Easements (continued)

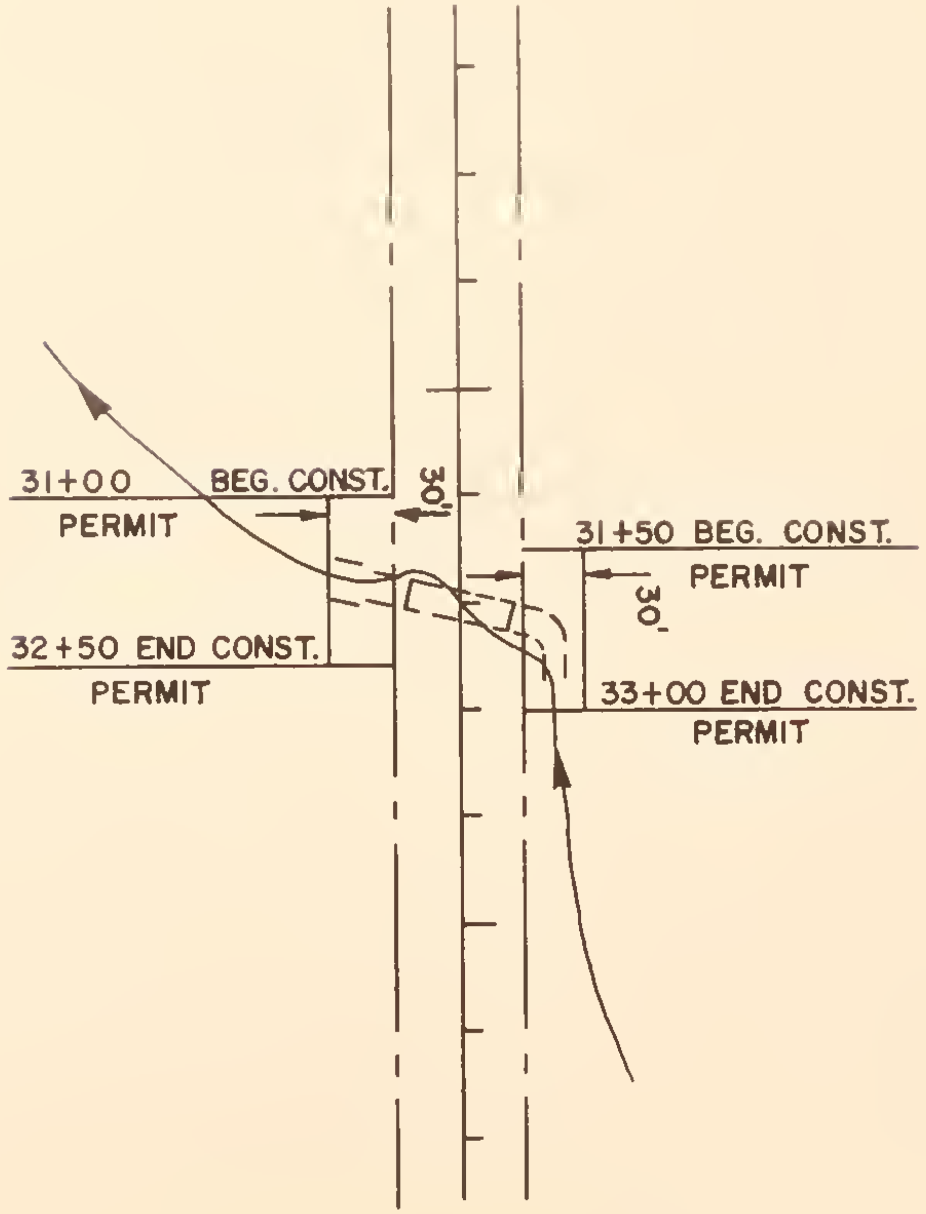
- Main supply irrigation canals (owned by the U.S. Government or an irrigation ditch company) should be outside the permanent highway right-of-way. Obtain separate right-of-way or a permanent easement which later may be deeded to the ditch company.



- Right-of-way should be designed to include channel changes for drain ditches, streams or rivers.

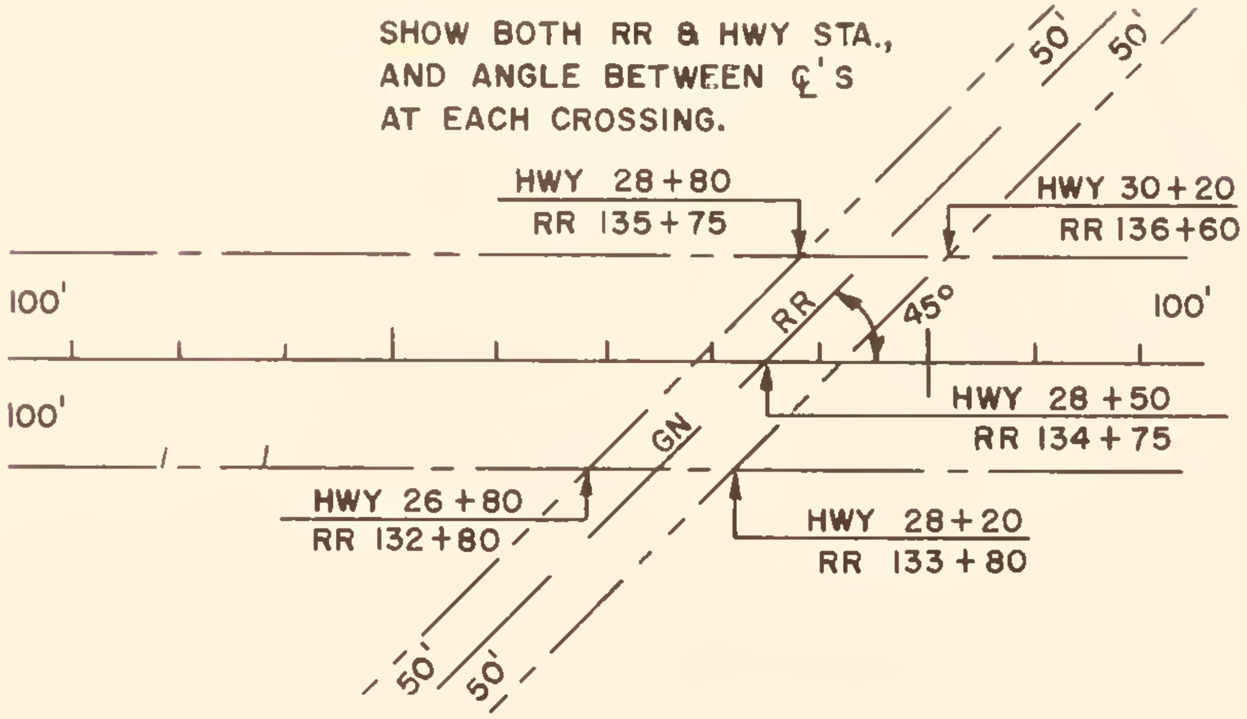


A construction permit normally will be adequate for minor inlet and outlet ditches outside the regular highway right-of-way. If a concrete spillway or considerable riprap is to be built, additional right-of-way should be obtained to include the spillway.



Construction Permits and Easements (continued)

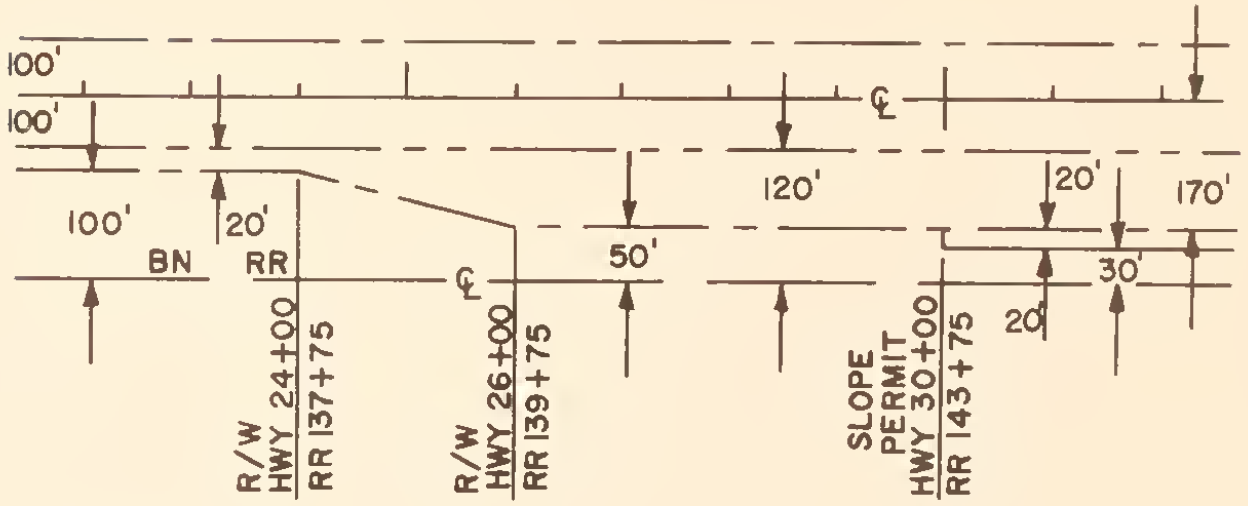
- Construction permits or easements will be required in the case of railroad crossings or encroachments that may occur when the alignment is parallel to the railroad. In cases where the highway centerline crosses the railroad centerline, it is necessary to show both the RR stationing and the highway stationing at the point of intersection, as well as the angle between the two lines.



- The following control clause should be provided on Interstate projects.

> "The controlled access highway does not allow any access between intersecting railroad property and the through lanes and ramps of the Interstate highway".

- On a parallel encroachment, it is necessary to show distances to the right-of-way from both RR and highway centerlines, and also the equivalent stationing at right-of-way breaks.



Access Control

When access control is specified (includes all Interstate projects), it is essential that the access control lines clearly be defined on the right-of-way plans.

The symbol for limited access fencing ordinarily is used to show the position of the access fence in relation to the centerline. In general, the fence is run along the right-of-way. The following are some exceptions:

- Where there is a frontage road, the fence is placed between the frontage road and the mainline.
- Access fences should tie into the ends of stockpasses or drains 5 feet in diameter or larger and to the ends of irrigation culverts 36" diameter or larger.

Access Control (Continued)

- Fences should tie into the ends of fences and grade separation structures. Where the cross road runs underneath, fences may run underneath the structure.
- If a portion of a utility line within the right-of-way may be left undisturbed, the access fence may be run inside the utility line so that it may be serviced.
- At all rural interchanges, access fencing should extend 300 feet along the crossroad from the ramp termini.

At places where access control is to be obtained, but fence is not to be installed, the access control is shown with this symbol: ▨▨▨▨▨ Examples of this application include:

- Access control lines along right-of-way where fences have been pulled into ends of pipes or bridges.
- Access control lines on right-of-way which is outside or beyond the actual access control fence.
- Access control lines on right-of-way bought for connections to the present traveled way.

U.S. Government Land

Where the proposed right-of-way is through land owned by the U.S. Government, the area of taking should be hatched with diagonal lines:

Indian Land

All Indian land required for right-of-way should be cross hatched, and allotment numbers should be shown.

State of Montana Land

In the case of land owned by the Department of State Lands, the following information must be shown on the plans for each 40-acre subdivision, U.S. Government lot, or any portions thereof.

Gross right-of-way acreage ______________
Existing right-of-way acreage ______________
Net right-of-way acreage ______________

Remainder on left ______________
Remainder on right ______________

In many instances a present road across state land constitutes an encroachment, since no right-of-way easement was issued. In such instances, the P.T.W. is not to be shown as existing right-of-way but must be included in the gross right-of-way acreage and the net right-of-way acreage.

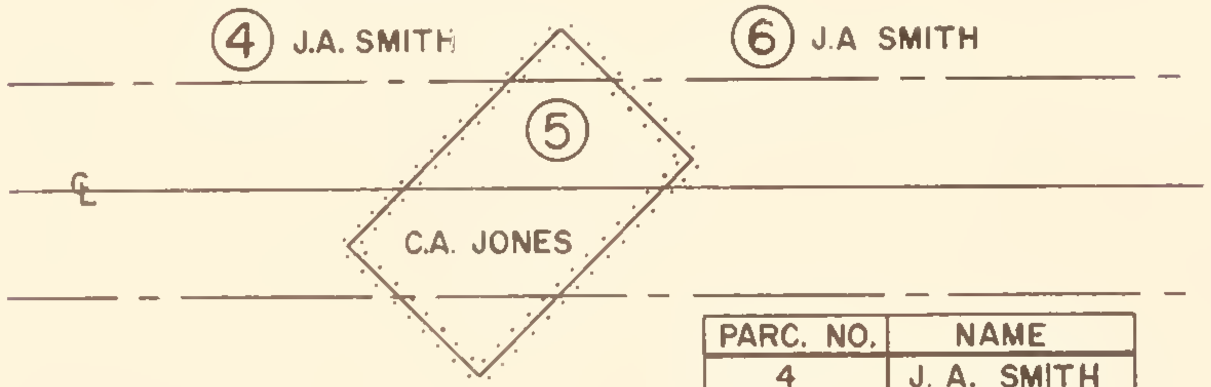
Parcel Numbers

Parcel numbers are for convenience in identifying the different land parcels to be acquired for a specific project. Parcels should be numbered consecutively, commencing at the beginning of the project on the left side of centerline.

Parcel Numbers (continued)

The following criteria should be kept in mind:

- Where there is complete severance as shown below, the separated portions of the same owner are given different parcel numbers and a combination parcel shown in the last sheet where there is land to be purchased from that particular owner.



PARC. NO.	NAME
4	J. A. SMITH
5	C. A. JONES
6	J. A. SMITH
4 & 6	J. A. SMITH

- Different parcel numbers for the same owner are necessary where a dedicated street or alley separates the lots of that owner.

- Different parcel numbers for the same owner are necessary where a project runs from one county into another.

- Where existing right-of-way is adequate, it is not necessary to assign a parcel number unless the grade change may cause damage to the property.

- Two parcel numbers are necessary if one portion of the land is in the wife's name and another portion is in the names of both husband and wife. However, if one portion of the parcel is in the husband's name while the adjoining portion is in both names, one parcel number will be sufficient.

- Where additional width or length of a parcel is required subsequent to acquistion of the original parcel, and a second deed is required from the same owner, the additional parcel should be identified with the original parcel number and a letter suffix.

- An addition in width or length of a parcel prior to acquisition of the original right-of-way requires revision of the description and retention of the original parcel number.

- A parcel originally under one ownership, but which is divided into two or more ownerships prior to acquisition, requires treatment as two or more individual parcels. The original parcel number will be retained for that portion still under the original ownership. Portions under new ownership will be given the same parcel number, but with a decimal numeral suffix, such as 1.1, 1.2, 1.3, etc.

- In the case of contract purchase of an entire tract, a single parcel number is assigned to the present owner (the name and the address of the purchaser is identified). If the contract purchase involves only a portion of the tract, two separate parcel numbers are required.

Parcel Numbers (continued)

- Material sites and haul roads will be identified by separate parcel numbers consisting of letters indicating the nature of the parcel followed by the numbers of the parcel. Indentifying letters shall be M S for gravel sources; B P for borrow pits; and H R for haul roads.
- Temporary construction permits require a parcel number unless acquired with another parcel.
- Any property right (private and corporate ownership) that will be affected by highway construction activities requires identification by a parcel number.

Area Determination

When computing areas of "takes", anything less than one acre should be computed and recorded to the nearest square foot.

Takes greater than one acre should be computed and recorded to the nearest 1/10 acre.

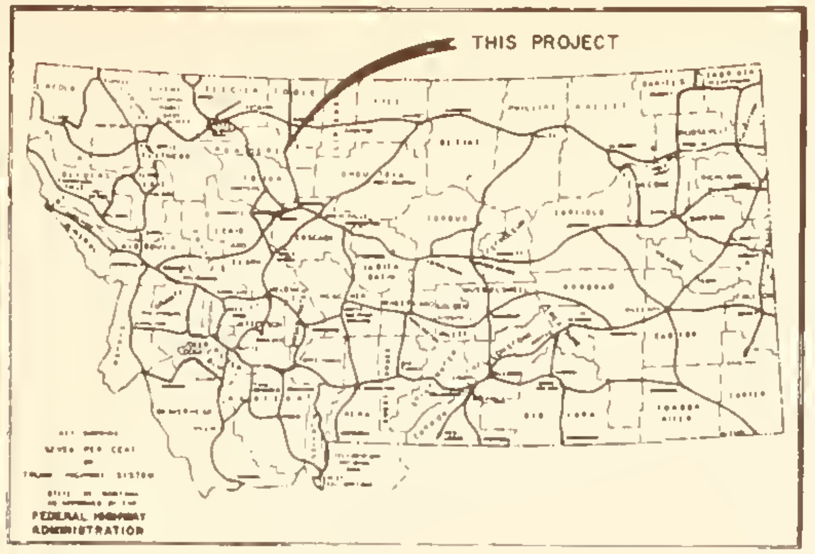
Areas of remainders left and right should be computed and recorded to the nearest 1/10 acre.

Remainders of urban lots should be computed to the nearest square foot.

Total areas will be identified and furnished by the Bureau of Right-of-Way.

Example Right-of-Way Plans

The following pages illustrate examples of a typical title sheet, ownership location map and right-of-way plan sheet.



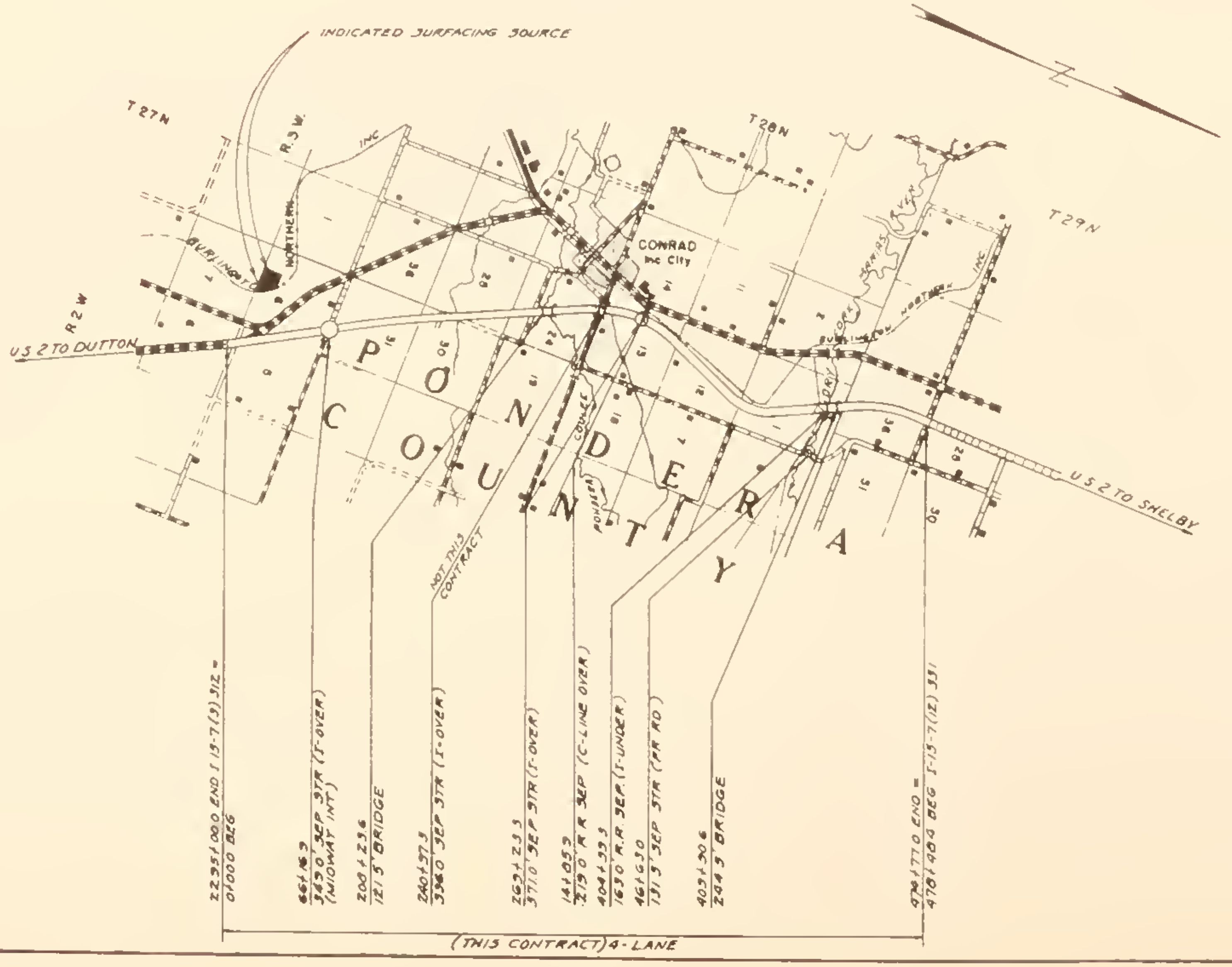
MONTANA DEPARTMENT OF HIGHWAYS

FEDERAL AID PROJECT I-IG 15-7(6)323

RIGHT OF WAY PLANS
CONRAD NORTH & SOUTH
PONDERA COUNTY

LENGTH 9.0 **MILES**

SCALES
HORIZONTAL: 1 Inch = 100 Feet
VERTICAL: 1 Inch = 10 Feet
CROSS SECTIONS--HOR. & VERT.: 1 Inch = $\frac{10}{20}$ Feet
REDUCED PRINTS APPROX 1/2 ORIGINAL SCALE


INDICATED SURFACING SOURCE
N
T27N
R3W
T28N
T29N
R2W
BURLINGTON NORTHERN INC
CONRAD Inc City
US 2 TO DUTTON
US 2 TO SHELBY
PONDERA COUNTY
NOT THIS CONTRACT
2235+00.0 END I 15-7(3)312 = 0+00.0 BEG
66+63 345.0' SEP STR (I-OVER) (MIDWAY INT)
200+23.6 121.5' BRIDGE
240+57.3 336.0' SEP STR (I-OVER)
265+23.3 371.0' SEP STR (I-OVER)
141+05.3 219.0' R R SEP (C-LINE OVER)
404+33.3 165.0' R.R. SEP. (I-UNDER)
461+63.0 131.5' SEP STR (PR RD)
403+30.6 244.5' BRIDGE
478+77.0 END = 478+40.0 BEG I-15-7(12)331
(THIS CONTRACT) 4-LANE

CONVENTIONAL SIGNS

RIGHT OF WAY LINE	
CENTERLINE (℄) OR PROJECTED LINE	
STK'D. CENTERLINE	
PARCEL NUMBER	②
OWNERSHIP BOUNDARY	
R/W USE EXISTING R/W LT OR RT	
PRESENT TRAVELED WAY (P.T.W.)	
R/W LINE FENCED	
RAILROAD R/W	
CONSTRUCTION LIMITS	CUT — FILL
FENCE LINE	
CONTROL OF ACCESS WITH FENCE	
CONTROL OF ACCESS WITHOUT FENCE	
GATE IN FENCE	
CATTLE GUARD: 24'	
STATE & NATIONAL BORDER LINES	
CITY OR TOWN LIMITS LINE	
COUNTY LINE	
RESERVATION LINE	
TOWNSHIP & SECTION LINE	
1/2 SECTION LINE	
1/4 SECTION LINE	FOUND UNFOUND
SECTION CORNER	
1/4 SECTION COR	
1/16 SECTION COR	
CENTER OF SECTION	○
TELEPHONE OR TELEGRAPH POLES IN PLACE	
POWER POLES IN PLACE	
TEL OR TEL OR POWER POLES TO BE MOVED	
NEW PIPES	
OLD PIPES IN PLACE	
OUTLET DITCH	
INLET DITCH	
DITCHES	
CHANNEL CHANGES	
BRIDGE	
RAILROADS	

RELATED PROJECTS
U-2 FENCING U-3 STRUCTURE F-149 (7)

ASSOCIATED PROJECT AGREEMENT NUMBERS	
CONST.	(13) 323
P.E.	(1) 328 (8) 323

MONTANA DEPARTMENT OF HIGHWAYS

APPROVED

________________ 19 ______

STATE HIGHWAY ENGINEER

No 174ES
LEWIS M CHITTIM

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

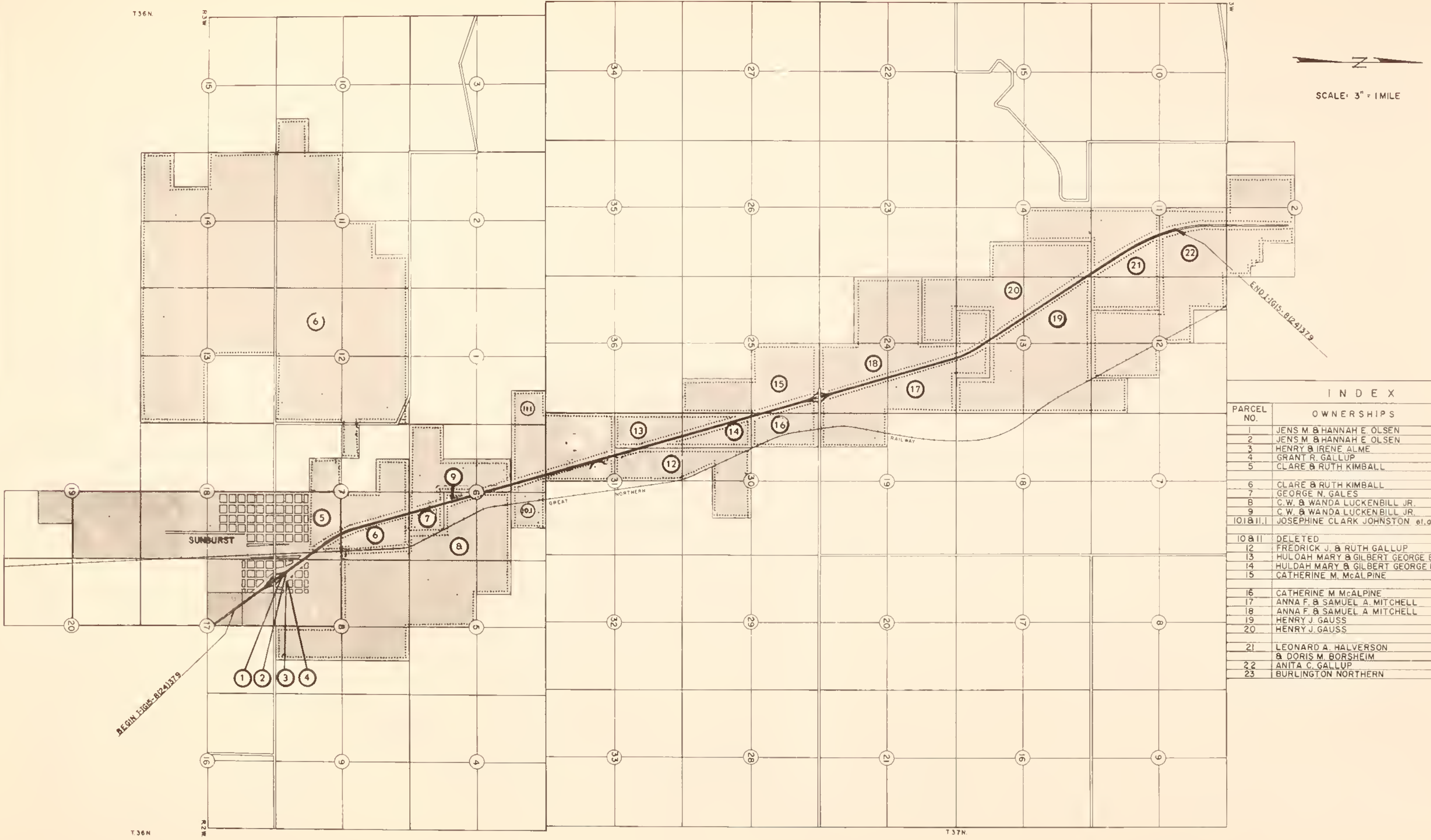
APPROVED

________________ ________

DIVISION ENGINEER DATE

OWNERSHIP LOCATION MAP

STATE	PROJECT NO	SHEET NO.
MONTANA	I-IG 15-8(24)379	



INDEX

PARCEL NO.	OWNERSHIPS	SHEET NO
1	JENS M. & HANNAH E. OLSEN	4
2	JENS M. & HANNAH E. OLSEN	4
3	HENRY & IRENE ALME	4
4	GRANT R. GALLUP	4
5	CLARE & RUTH KIMBALL	4
6	CLARE & RUTH KIMBALL	4,5 & 6
7	GEORGE N. GALES	6
8	C.W. & WANDA LUCKENBILL JR.	6 & 7
9	C.W. & WANDA LUCKENBILL JR.	6 & 7
10.1 & 11.1	JOSEPHINE CLARK JOHNSTON et.al	7,8 & 9
10 & 11	DELETED	8 & 9
12	FREDRICK J. & RUTH GALLUP	9
13	HULOAH MARY & GILBERT GEORGE EHLI	9 & 10
14	HULDAH MARY & GILBERT GEORGE EHLI	9 & 10
15	CATHERINE M. McALPINE	10 & 11
16	CATHERINE M McALPINE	10 & 11
17	ANNA F. & SAMUEL A. MITCHELL	11-14
18	ANNA F. & SAMUEL A MITCHELL	11-14
19	HENRY J. GAUSS	14 & 15
20	HENRY J. GAUSS	14 & 15
21	LEONARD A. HALVERSON	
	& DORIS M. BORSHEIM	15 & 16
22	ANITA C. GALLUP	16
23	BURLINGTON NORTHERN	11

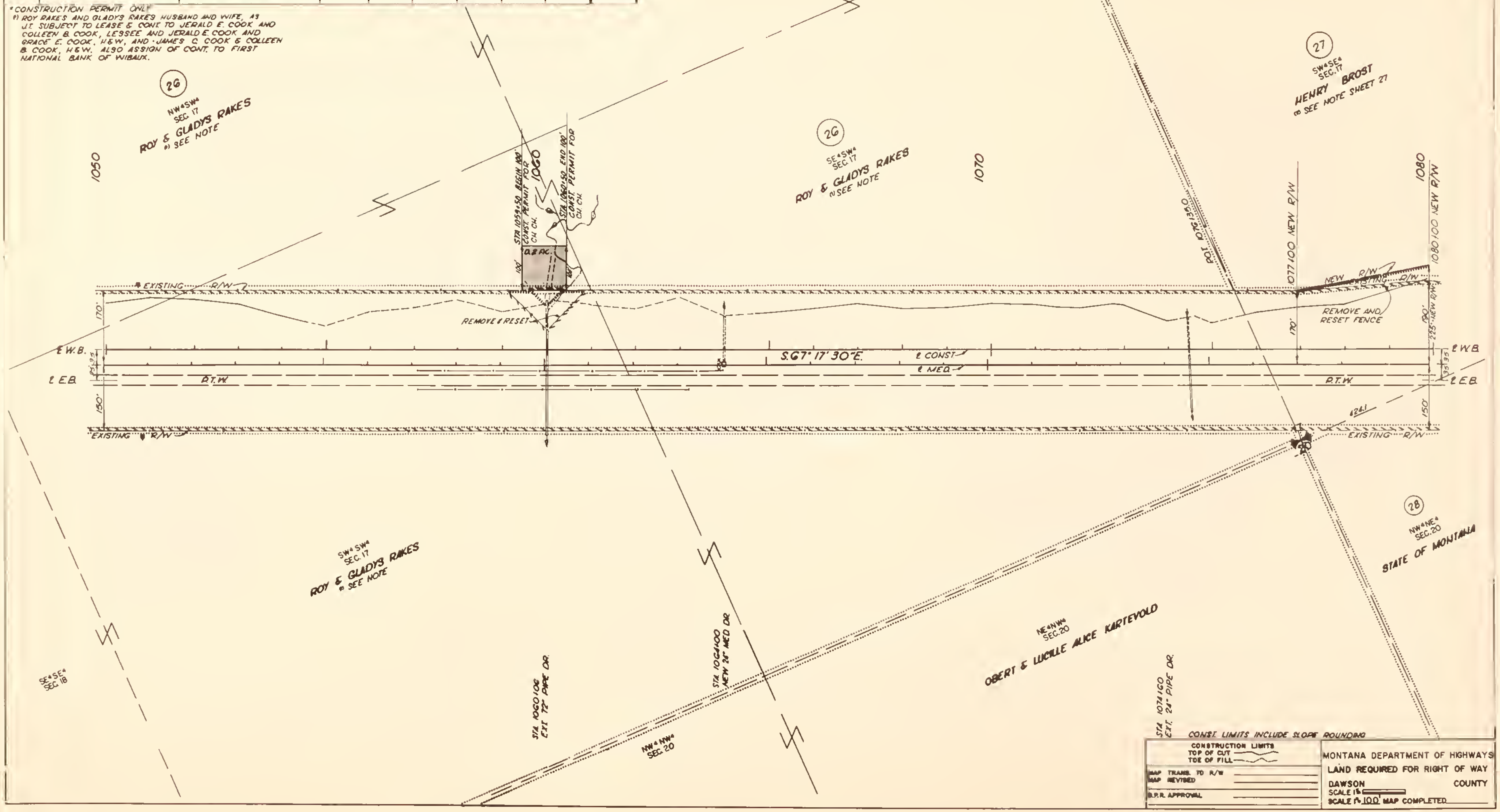
STATE	PROJECT NO.	SHEET NO.

OWNERSHIPS

PARCEL	NAME	ADDRESS	TOTAL AREA	GROSS R/W AREA	P.T.W. AREA	AREA TO BE ACQUIRED	REMAINDER LEFT	REMAINDER RIGHT	CONST. PERMIT AREA
*① 26	ROY & GLADYS RAKES	GLENDIVE, MONTANA							0.2
27	HENRY BROST	GLENDIVE, MONTANA							
28	STATE OF MONTANA								
21-29	ROY AND GLADYS RAKES		242.145	0.4	0	0.4	55.03	187.07	0.4

*CONSTRUCTION PERMIT ONLY

① ROY RAKES AND GLADYS RAKES HUSBAND AND WIFE, AS J.T. SUBJECT TO LEASE & CONT. TO JERALD E. COOK AND COLLEEN B. COOK, LESSEE AND JERALD E. COOK AND GRACE E. COOK, H&W, AND JAMES C. COOK & COLLEEN B. COOK, H&W. ALSO ASSIGN OF CONT. TO FIRST NATIONAL BANK OF WIBAUX.



CONST. LIMITS INCLUDE SLOPE ROUNDING

CONSTRUCTION LIMITS
TOP OF CUT
TOE OF FILL

MAP TRANS. TO R/W
MAP REVISED
B.P.R. APPROVAL

MONTANA DEPARTMENT OF HIGHWAYS
LAND REQUIRED FOR RIGHT OF WAY
DAWSON COUNTY
SCALE 1" =
SCALE 1" = 100' MAP COMPLETED

MISCELLANEOUS DESIGN

GENERAL CONSIDERATIONS

Several road design criteria are not directly related to the major topics covered elsewhere in this manual. These miscellanous criteria are presented in this chapter.

AIRWAY-HIGHWAY CLEARANCES

Within two miles of airports, highways must be designed to provide minimum clearances between the highways and the navigable airspaces. Navigable airspaces, minimum clearances and related criteria are discussed below.

Navigable Airspace

Navigable airspace at the ends of runways is defined on Standard Sheet No. 1201 for various types of airports. Navigable airspaces are the spaces inside the approach zones and above slope lines.

Minimum Clearances

The minimum vertical clearances between the near road shoulder and the navigable airspace are noted on Standard Sheet No. 1201.

Objects Affecting Navigable Airspace

Highway appurtenances such as overhead signs and light standards must not penetrate navigable airspace.

Reference

For detailed airway-highway clearance regulations, designers should refer to "Part 77, Federal Aviation Regulations," published by the Federal Aviation Administration, and PPM 20-13.

BRIDGE CLEARANCES

Standard Sheet No. 1202 sets forth minimum horizontal and vertical clearances between bridge structures and various types of highways passing under those structures.

GUARDRAIL

Guardrail will be specified where warranted by existing conditions. This section defines warrants for guardrail and describes special treatments to be included in the design.

Details for metal guardrail and median rail, together with details of alternate guardrail posts, are shown on Standard Drawing No. 85. Normally this standard will be applicable. A standard cable guardrail is shown on Standard Drawing No. 90. The cable guardrail may be used in unusual circumstances when specifically called for.

Guides for special installations may be found in the following Standard Drawings:

	Standard Drawing No.
Bridge End Treatment	86
Pier Treatment	87
Guardrail for R.R. Grade Crossings	88
Guardrail Terminal Sections	89

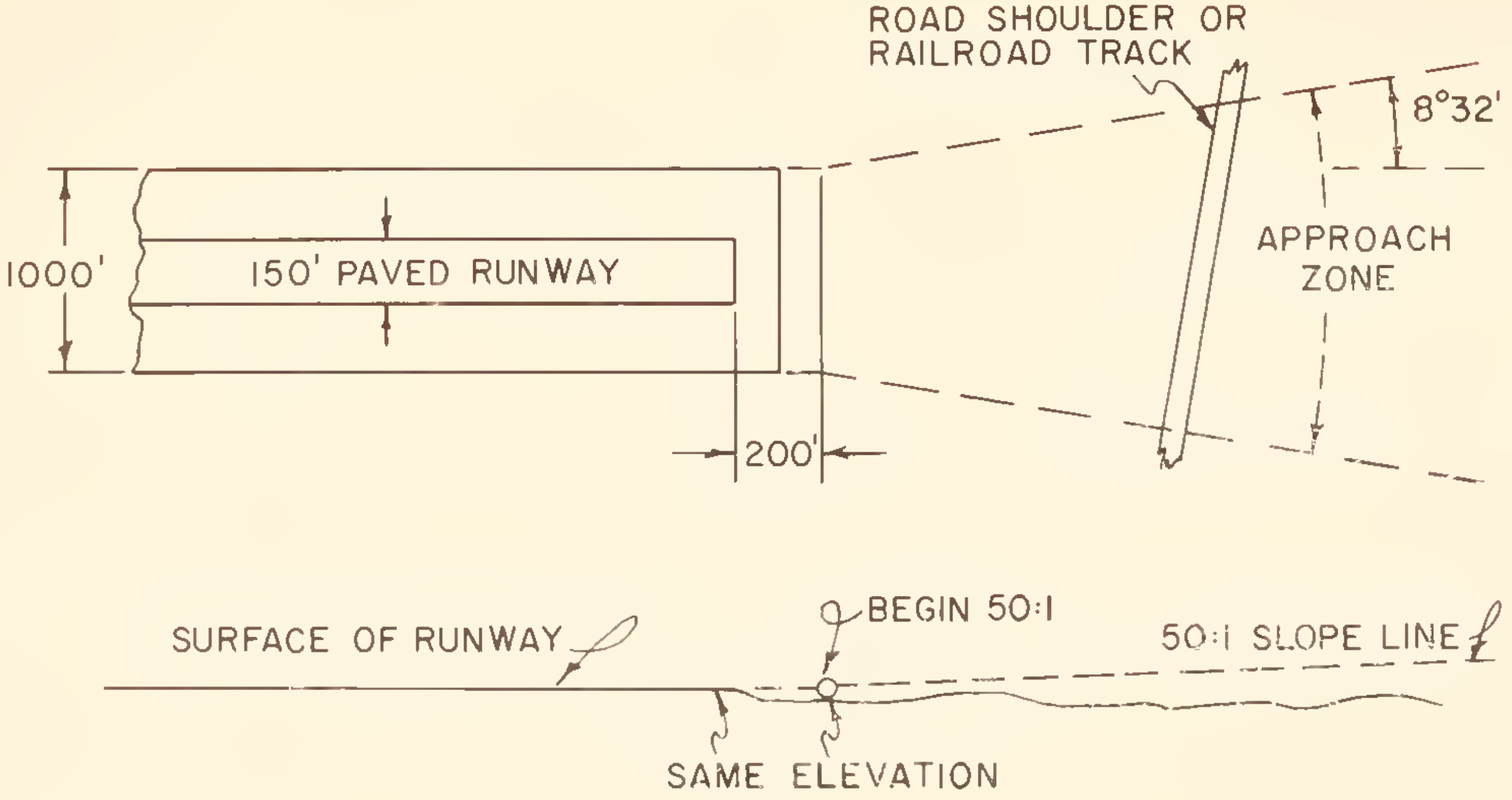
Specific warrants and applications are described below:

High Fills

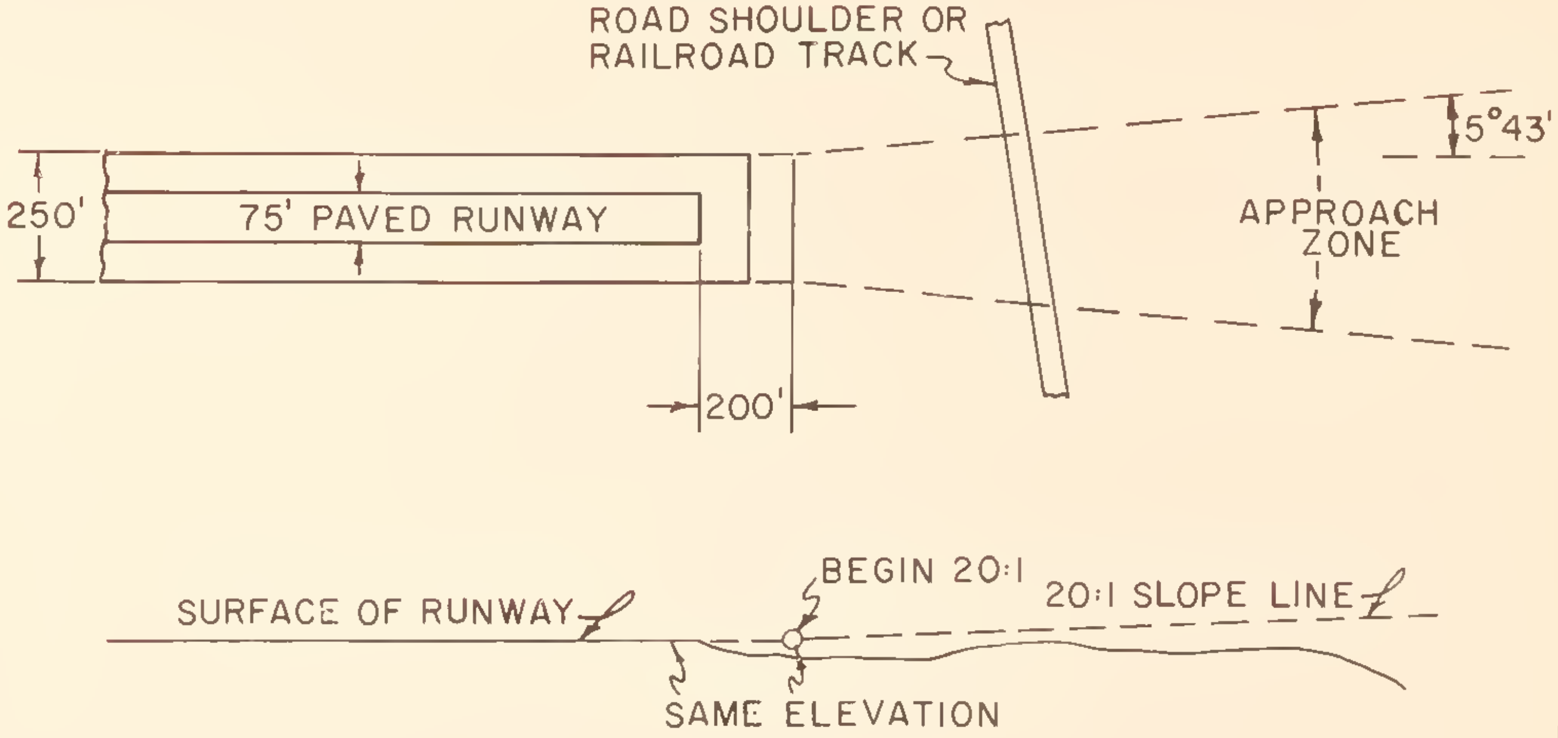
Guardrail is required for all 2:1 fill slopes where the fill height is 20 feet or more on curves and 25 feet or more on tangents.

In addition, other factors should be evaluated when considering the need for guardrail installations. At locations where it is concluded that guardrail may be required, guardrail warrants will be determined from a "hazard profile" developed by the designer.

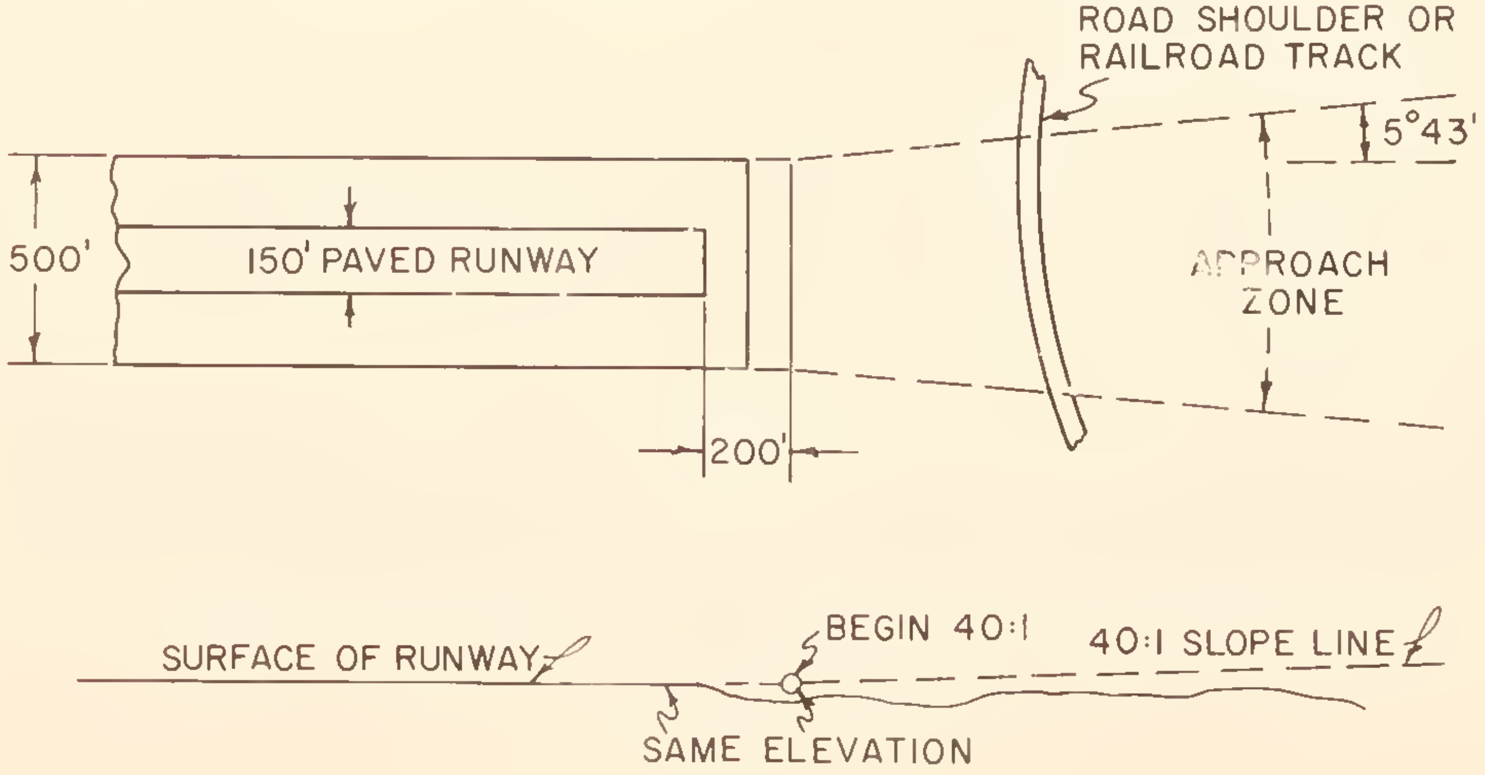
PAVED RUNWAY-INSTRUMENT



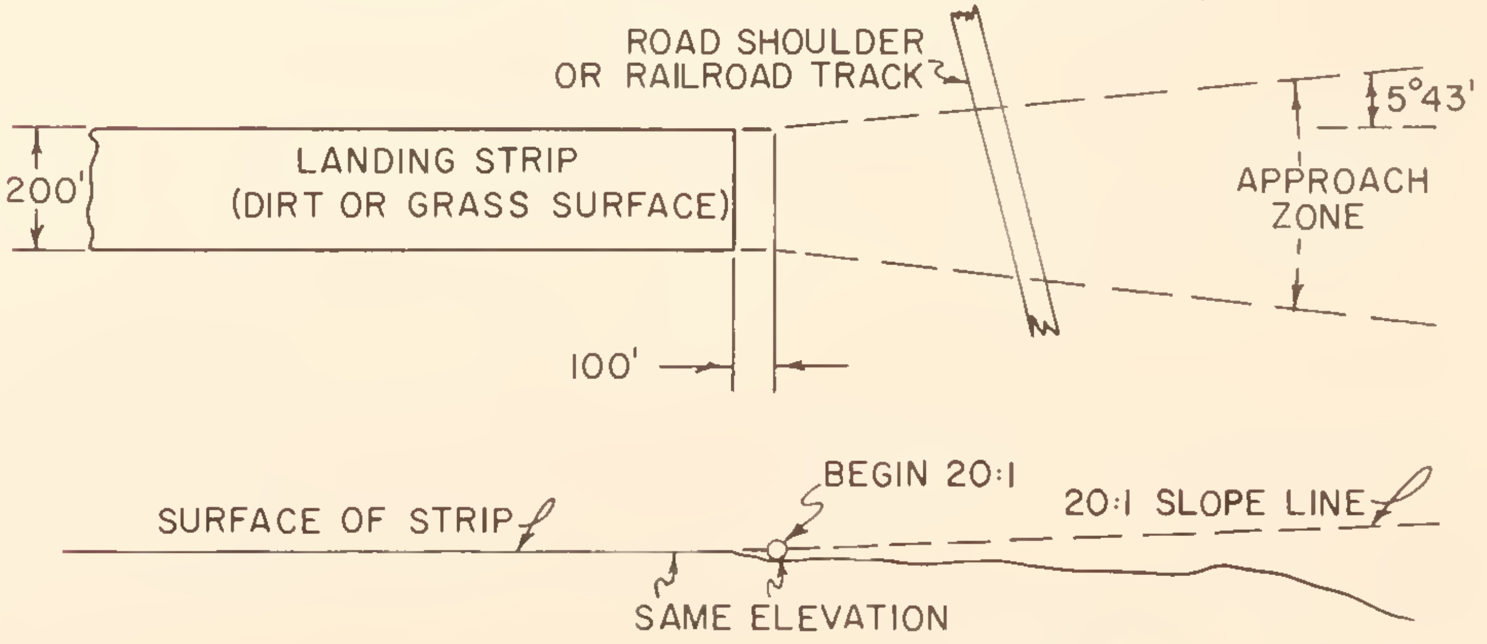
UTILITY AIRPORT



PAVED RUNWAY-NON INSTRUMENT



GENERAL SMALL AIRPORT (VFR)



NOTE: The slope line must clear or be above the near road shoulder at least 15' on Primary and Secondary routes and 17' on Interstate routes. Minimum clearance over railroad tracks is 25 feet.

REVISIONS	
DATE	BY

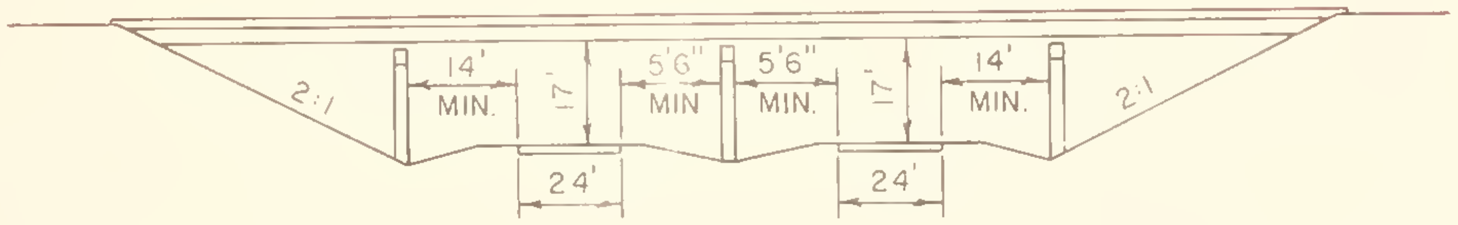
MONTANA
DEPARTMENT OF HIGHWAYS

AIRWAY – HIGHWAY
CLEARANCES

APPROVED
STATE HIGHWAY ENGINEER

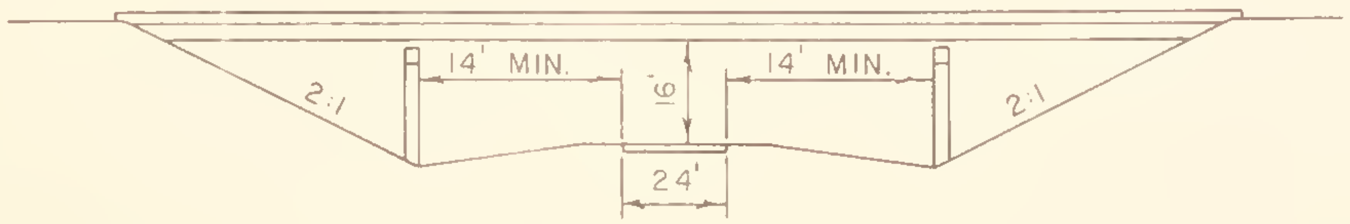
STANDARD SHEET NO. 1201

INTERSTATE HIGHWAY 1/



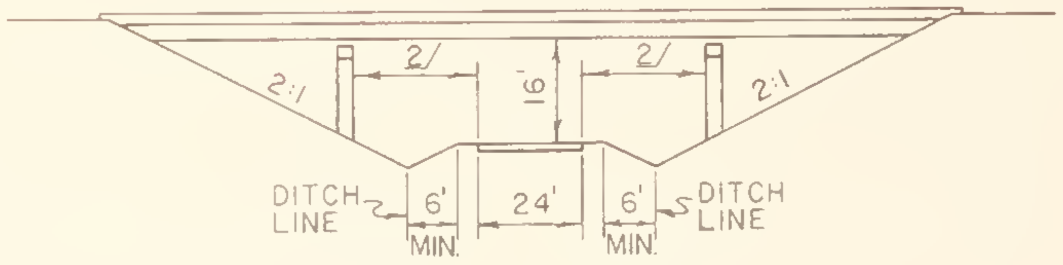
MAJOR PRIMARY OR SECONDARY HIGHWAYS 1/

(DESIGN SPEED=50 M.P.H. OR GREATER, CURRENT ADT=750 OR MORE)



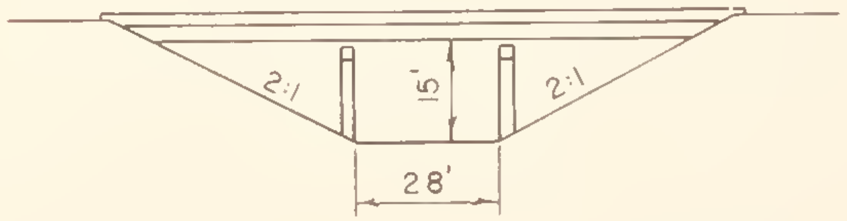
PRIMARY, SECONDARY, COUNTY ROADS AND INTERCHANGES

(CURRENT ADT LESS THAN 750)



LOW VOLUME-LOW SPEED ROADS 3/

(LESS THAN 50 ADT FUTURE TRAFFIC COUNT)



1/ ALL HORIZONTAL CLEARANCES SHOWN ARE ABSOLUTE MINIMUM. THE DESIRABLE MINIMUM IN EACH CASE IS 30'. WHERE 30' IS NOT AVAILABLE OR FEASIBLE, USE GAURDRAIL ACCORDING TO STANDARD DRAWING B7.

2/ VARIES-BENTS SHALL BE LOCATED TO CLEAR DITCH LINES AND OFFSET FROM SHOULDERS AS FAR AS PRACTICABLE.

3/ THE VERTICAL CLEARANCE WILL BE 14' FOR MINOR ACCESS STRUCTURES.

REVISIONS	
DATE	BY

MONTANA
DEPARTMENT OF HIGHWAYS

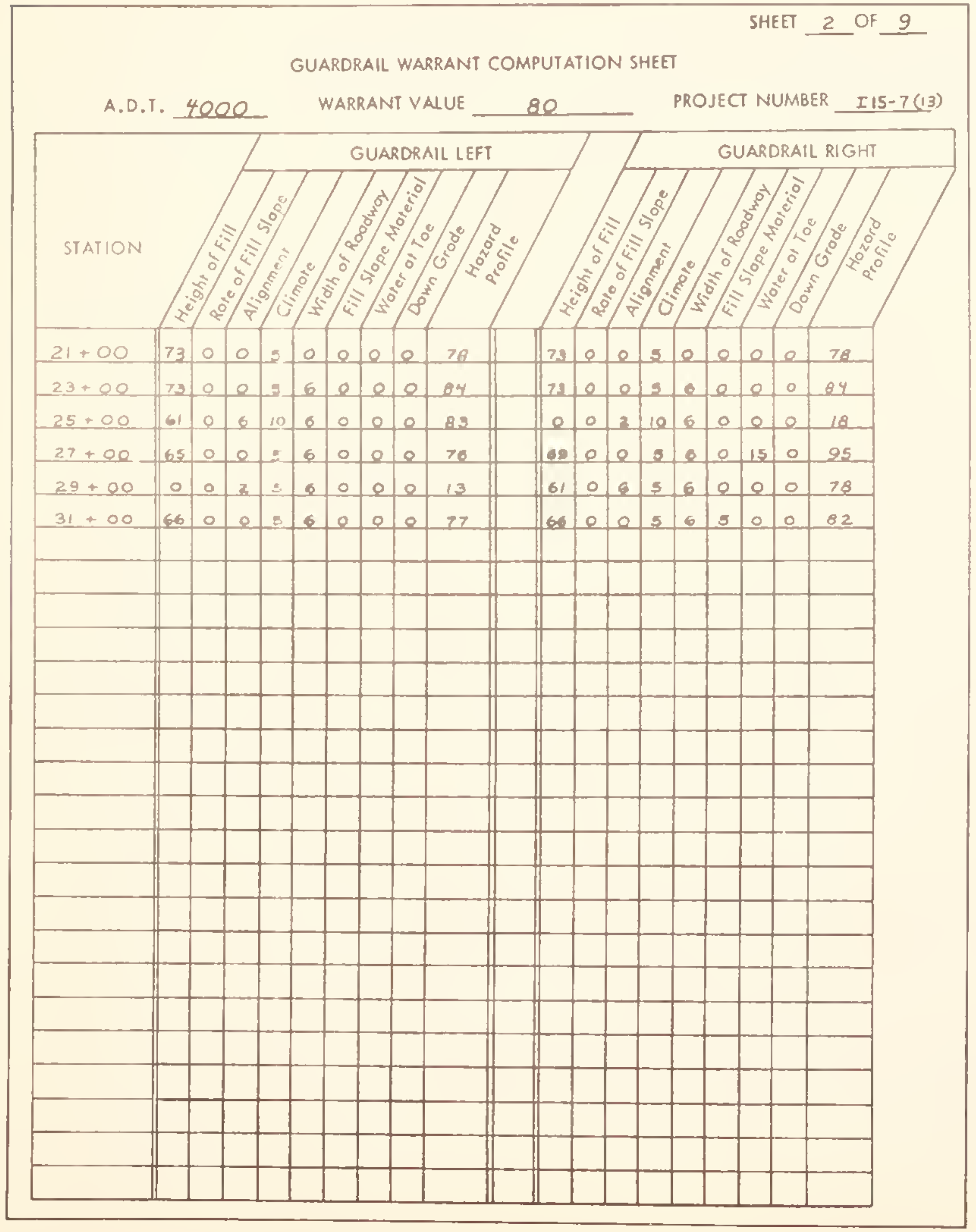
STANDARD BRIDGE
CLEARANCES

APPROVED

STATE HIGHWAY ENGINEER

STANDARD SHEET NO 1202

An example guardrail warrant computation sheet is shown below. As the headings indicate, guardrail warrant computations are made for individual stations on each side of the roadway. Hazard values are recorded for eight criteria at each station, and the sums of the values are recorded in the Hazard Profile columns.



SHEET 2 OF 9

GUARDRAIL WARRANT COMPUTATION SHEET

A.D.T. 4000 WARRANT VALUE 80 PROJECT NUMBER I15-7(13)

STATION	GUARDRAIL LEFT									GUARDRAIL RIGHT								
	Height of Fill	Rate of Fill Slope	Alignment	Climate	Width of Roadway	Fill Slope Material	Water at Toe	Down Grade	Hazard Profile	Height of Fill	Rate of Fill Slope	Alignment	Climate	Width of Roadway	Fill Slope Material	Water at Toe	Down Grade	Hazard Profile
21 + 00	73	0	0	5	0	0	0	0	78	73	0	0	5	0	0	0	0	78
23 + 00	73	0	0	5	6	0	0	0	84	73	0	0	5	6	0	0	0	84
25 + 00	61	0	6	10	6	0	0	0	83	0	0	2	10	6	0	0	0	18
27 + 00	65	0	0	5	6	0	0	0	76	69	0	0	5	6	0	15	0	95
29 + 00	0	0	2	5	6	0	0	0	13	61	0	6	5	6	0	0	0	78
31 + 00	66	0	0	5	6	0	0	0	77	66	0	0	5	6	5	0	0	82

The following hazard values will be used:

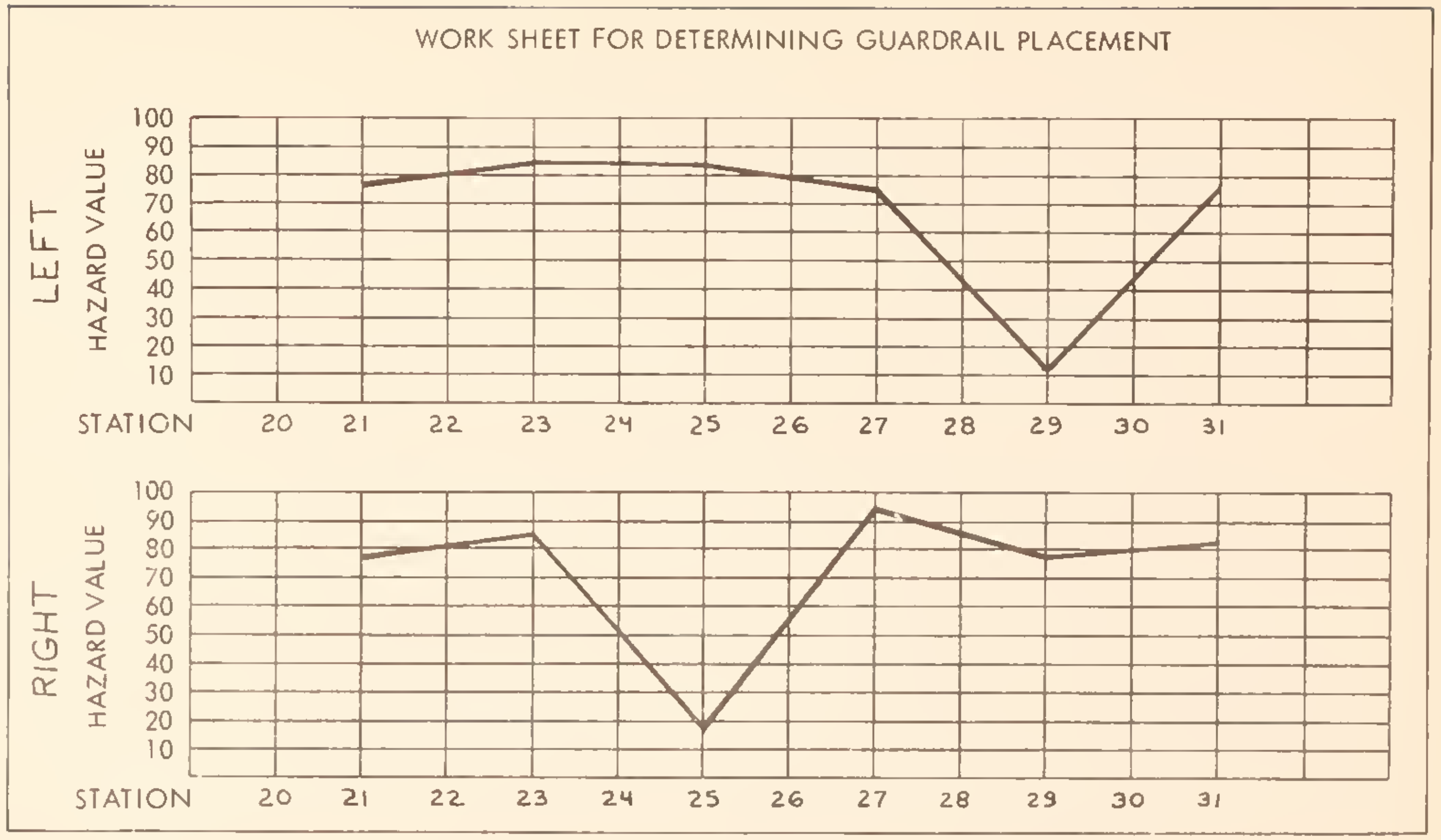
Criteria	Hazard Values
Height of fill	
Less than 5'	0
Over 5'	55 + height of fill
Rate of fill slope	
2:1 and steeper	0
3:1	-20
4:1	-50
Alignment	
Outside of curve	2 points per degree of curve
Inside of curve	½ point per degree of curve
Note: Round fractional values to the next highest whole number.	
Climate	
Western Montana	10
Eastern Montana	7
Note: Multiply hazard value by 2 where roadway is shaded	
Width of roadway (traffic lanes plus shoulders)	
20' - 25'	9
25' - 31'	6
31' - 39'	3
39' and over	0
4-lane divided highway	0

Criteria	Hazard Values
Fill slope material	
Sand, soil, gravel	0
Broken rock, average size 2½' and over	5
Water at toe of fill	
Less than 3' deep	5
3' - 6' deep	15
6' deep and over	30
Down grade (percent)	
0 - 3	0
4 - 6	5
7 - 10	8

The values in the Hazard Profile columns will be plotted by station as shown in the example work sheet on the right.

A horizontal warrant line will be established on the plotted hazard profile, based on the average daily traffic (ADT) as follows:

ADT	Warrant Value
0 - 500	100
500 - 1000	90
1000 - 5000	80
5000 and over	70


WORK SHEET FOR DETERMINING GUARDRAIL PLACEMENT

Generally, guardrail will be installed along those sections of the highway where the hazard profile is higher than the warrant line. But the following considerations should be kept in mind:

- Where the hazard profile indicates a need for many short sections of guardrail, the designer should realize that such installations would be hazardous and impractical. Long continuous sections of guardrail are preferable to many short sections.
- On four-lane projects, determine the lengths of guardrail required by the hazard profile -- then shift the entire installations 100 feet against the direction of traffic.
- Special terminal sections should be specified according to the guidelines on Standard Drawing No. 89.

Bridge End Treatment

Guardrail will be placed at all bridge ends on two-way roads and the approach ends of bridges on one-way roads. Typical bridge end treatments are shown on Standard Drawing No. 86.

The Type 1 approach section is applicable to all new bridges. The Type 2 approach section should be used for existing bridges where anchor posts are in place. The Type 3 approach section is applicable to existing bridges without anchor posts.

These transition sections utilize 12" x 12" posts rather than the conventional 8" x 8" posts used in normal guardrail installations, and the posts are spaced closer together. Each bridge approach section of steel guardrail (as indicated on the Standard Drawing) is measured and paid for as one unit. The lineal feet of such rail should not be included with other guardrail quantities.

At the departure end of one-way traffic structures, normal 8" x 8" posts and 6' - 3" spacing can be used.

Existing structures may require special design by the Bureau of Bridge Design.

At each approach installation, guardrail will be required in addition to that provided by Standards Drawing No. 86. This may be in the form of a terminal section or an extended length of guardrail plus a terminal section, as warranted by local conditions. In either case, the additional guardrail will be measured and paid for on a lineal feet basis.

Bridge Pier Treatment

Guardrail will be installed at all locations where bridge piers are closer than 30 feet from the edge of the nearest traffic lane. Standard Drawing No. 87 shows typical guardrail installations for protection at bridge piers in the median and along the outside shoulders.

Railroad Grade Crossing Protection

Because of the proximity of railroad crossing signals to the traffic lanes, special guardrail protection usually will be required at these locations. A typical installation is shown on Standard Drawing No. 88.

Guardrail Terminal Sections

Several alternative guardrail terminal sections are shown on Standard Drawing No. 89. The designer should specify the types of terminal sections appropriate for individual conditions. Criteria for determining the proper terminal sections are presented below:

- Terminal Section 1 -- To be used at the beginning and end of all guardrail installations on 2-lane, 2-way highways. Also to be used for connection with bridge approach rail section types 1 and 2 on 2-lane highways.
- Terminal Section 2 -- To be used on 4-lane, one-way highways at the departure ends of normal guardrail installations. Also to be used for connection with bridge approach rail section type 1 at the departure ends of one-way bridges when the warrant value of the locations indicates the need for guardrail.
- Terminal Section 3 -- To be used only with Type 3 bridge approach rail sections where continuous rail is not required.

- Terminal Section 4 -- To be used only with type 3 bridge approach rail sections as an intermediate transition where continuous rail is required.
- Terminal Section 5 -- To be used at the approach ends of normal guardrail installations on 4-lane divided highways. Also to connect with the approach end of bridge approach rail sections types 1 and 2 on 4-lane divided highways where continuous rail is not required.
- Terminal Section 6 -- To be used only for special installations where the ends of the sections may be embedded in cut slopes.

Terminal sections of guardrail will be measured in the lineal feet.

CATTLE GUARDS

Cattle guards, as detailed on Standard Drawing No. 79, will be specified according to the design policies and criteria presented below.

Approaches

The types, lengths and locations of cattle guards to be installed at approaches will be identified in the Fencing Summary prepared by the Right-of-Way Division. All cattle guards at approaches will be placed on the right-of-way line.

Interchange Ramps

Where cattle guards are required on interchange ramps, try to provide at least 150 feet between the ramp terminal and the cattle guard. The cattle guard will extend the full width of the ramp pavement -- from finished shoulder to finished shoulder.

Quantity Estimates

Cattle guards are available in standard sections of two sizes: 10' x 8' and 12' x 8'. Two 12' x 8' sections (for a 24' roadway) will be adequate for most situations. In all cases, the cattle guard will equal the width of the finished roadway plus finished shoulders.

Cattle guards for each project will be itemized in a separate summary similar to the model summary in Chapter Fifteen.

CONCRETE SLOPE PROTECTION

Concrete slope protection, as detailed on Standard Drawing No. 27, will be specified for use on bridge end slopes.

Quantities of concrete slope protection will be estimated as "square yards of concrete."

MONUMENTS AND MARKERS

Standard designs and location criteria for various monuments and markers are shown on Standard Drawing No. 104.

For each project, designers will tabulate the numbers of right-of-way monuments, station markers and project markers. The number of each type will be shown in a monuments and markers summary similar to the model summary in Chapter Fifteen.

Right-of-Way Monuments

Right-of-way monuments are required on all rural projects. One monument should be set at each of the following points:

- At each point where the right-of-way width changes
- At each P.C. and P.T. on simple curves
- At each T.S., S.C., C.S. AND S.T. on spiral curves

Where it is undesirable to set concrete right-of-way monuments, such as on lot or block lines in an urban area, the concrete monuments will be ommitted and iron pipes or pins will be placed by Department personnel.

On projects where the existing right-of-way will be altered, the existing monuments should be reset. The summary frame should separately identify the quantities of new monuments and monuments to be reset.

Station Markers

Station markers are required on Primary and Interstate projects only. Station markers are to be set opposite every tenth station and at equations of 100 feet or longer.

Project Markers

Project markers are required on all projects. Ordinarily, two markers must be set -- one at the beginning and one at the end of each project. For some projects, where one of the two markers already has been set, only one marker will be required.

FENCING

It is the general policy of the Department to provide continuous fencing on the right-of-way line for all federal-aid projects. Exceptions may be made when fencing is not necessary because of the size and use of a particular tract of land, the presence of natural barriers, or the absence of livestock. Final determinations will be made on the basis of the recommendations of the District Engineer and the right-of-way negotiations.

Fencing Plans

For complex fencing situations, special fencing plans will be prepared. However, a summary in the construction plans usually will suffice. Right-of-way plans will be used as base maps for this purpose, with the exact location of control of access fencing and other fencing requirements clearly defined. Criteria for the design of fencing for control of access are presented in Chapter Eleven.

Ordinarily, fencing will be included in the prime road contract, with a special provision stating that fencing will be one of the first major items of construction to be accomplished.

Occasionally some sections of fence may be constructed by the landowner as a result of right-of-way negotiations. Payment is made directly to the landowner. These particular fence sections should not be included with the road construction contract.

Types of Fence

The various types of standard fences to be constructed by the Department are shown on Standard Drawing Nos. 75 through 78. Details of gates and posts also are shown.

Decisions as to the types of fences, gates and cattle guards to be provided will be made during right-of-way negotiations for individual land parcels. These determinations will be documented by the Bureau of Right-of-Way and submitted to the highway designer in the form of a complete summary of project fencing requirements. Agreements for fencing to be performed by landowners will be clearly identified.

Temporary Fencing

All rural projects which require permanent fencing will include 50 rods of fence per mile to be used as temporary fencing during construction.

RETAINING WALLS

An expected need for retaining walls will be noted in the Planning Report. Preliminary location of the retaining wall will be established during preliminary design. Where retaining walls are deemed necessary, quantities will be computed in square feet of face area.

All retaining walls will require special design. Specifications and design plans for complex installations will be provided by the Bureau of Bridge Design.

The final design of retaining walls will be reviewed during the final P.I.H. inspection.

CURB AND GUTTER

Various types of standard curbs and curb and gutter are described on Standard Drawing Nos. 66 through 68. Criteria and policies for their use are presented below:

- Integral Curb and Gutter (Concrete) -- To be used for city streets and other locations where surface drainage is a major consideration.

- Simple Curb (Concrete) -- To be restricted for use in situations where permanent curb is desirable and surface drainage is not a major consideration.

- Bituminous Curb -- To be used only in conjunction with embankment protector installations.

- Precast Concrete Median Curb -- To be restricted for use in traffic channelization -- such as rest areas and traffic islands -- where it periodically may be necessary to relocate the curbs to meet changing traffic needs.

All curb and gutter quantities will be estimated in linear feet and set forth in a summary similar to the model curb and gutter summary in Chapter Fifteen.

CLEARING AND GRUBBING

Clearing and grubbing usually will be included in the general contract and will not require separate plans. If clearing and grubbing is a separate contract, separate plans will be developed based on the right-of-way plan masters.

Decisions related to the payment method -- lump sum, absorbed in other bid items, or by the acre -- will be made during the preliminary P.I.H. Payments based on the number of acres involved will require the quantities to be shown in the plan summaries. When clearing and grubbing are to be absorbed or paid for in a lump sum, the appropriate note will be included on the Notes sheet. Clearing and grubbing may be bid as separate bid items with different bases for payment or as a single item.

Decisions related to the disposition and areas of selective cutting will be made at the final P.I.H.

The disposition of merchantable timber will be determined during right-of-way negotiations.

RIPRAP

Specifications, quantities and design data for riprap installations at structure locations will be furnished by the Bureau of Bridge Design.

Data and criteria for riprap installations for pipe and channel change facilities are shown on Standard Drawing Nos. 25 and 26. Recommendations for special riprap, complex installations, and the type of riprap to be used will be furnished by the Hydraulics Unit.

QUANTITY ESTIMATES

Chapter Thirteen

QUANTITY ESTIMATES

GENERAL CONSIDERATIONS

When making quantity estimates, the designer should consider the following items:

- Rounding procedures
- Degrees of accuracy required for estimating various quantities
- Quantity splits for the project
- Cost estimates.

These items are discussed below.

ROUNDING PROCEDURES

For estimating purposes, most quantities will be rounded using the basic procedure presented below. A few quantities must be rounded using special procedures.

Basic Procedure

The basic procedure for rounding quantity estimates is presented below:

1. Determine the last digit to be used.

2. If the digit following the last digit to be used is 4 or less, drop it and all that follow it. Do not change the last digit to be used.

3. If the digit following the last digit to be used is 5 or more, drop it and all that follow it. Add 1 to the last digit to be used.

Special Rounding Procedures

Special rounding procedures are to be used for estimating quantities of culvert excavation, guardrail, pipe culverts and embankment protectors.

Culvert Excavation

Quantities of culvert excavation under 5 cubic yards will be rounded up to 5 cubic yards. Quantities of culvert excavation over 5 cubic yards will be rounded to the nearest multiple of 5 cubic yards.

Guardrail

Guardrail is available in length increments of 12.5 feet. Where the length needed is not a multiple of 12.5 feet, round up to the next largest multiple of 12.5 feet.

Pipe Culverts and Embankment Protectors

Pipe culverts and embankment protectors are available in length increments of 2 feet. Where the lengths needed are not multiples of 2 feet, round up to the next largest multiple of 2 feet.

DEGREES OF ACCURACY

Generally, quantity estimates should be rounded to the nearest whole units used as the bases for payments. These units are set forth in the Standard Specifications. Exceptions to this rule are listed below:

ITEM	ROUND ESTIMATES TO THE FOLLOWING
Culvert Excavation	Multiples of 5 cubic yards
Embankment protectors	Multiples of 2 feet
Guardrail	Multiples of 12.5 feet
Pipe culverts (all types)	Multiples of 2 feet
Pneumatically applied mortar	0.1 square yards

QUANTITY SPLITS

Quantities on the plans must be separately identified, or "split," for each funding arrangement, county, type of work ond for each of several other criteria. For projects requiring quantity splits, the summary frames will be organized so that the subtotal for each split and the total of all splits can be readily identified. Designers should be guided by the model summary frames in Chapter Fifteen.

Funding Splits

Quantity splits are required for all projects involving different funds ond all primary and secondary projects where there is railroad participation. Generally, project designations such as UF, US, I , IG, etc. indicate the sources of the funds. Quantities will be split according to the limits described in PPM 21-10.

Quantities will be split where the federal government participates only in certain items or sections in o project. For example, the federal government moy not participate in certain detours and miscellaneous improvements on the periphery of a project.

County Splits

For all projects involving more than one county, the quantities within the boundaries of each county will be separately identified.

Rurol, Municipal and Urban Splits

Quantities for Interstate, Primary and Secondary projects must be split among rural, municipal and urban areas as defined below:

- Rural -- areas outside the limits of incorporated cities or towns
- Municipal -- areos within the limits of incorporated cities or towns of less than 5,000 population
- Urban -- areas within the limits of incorporated cities or towns of more than 5,000 population.

Quantities for rural-urban extension projects will be separately identified only when urban funds are involved.

Two-lane and Four-lane Splits

Quantities for all projects must be split between portions involving two lanes and portions involving four lanes.

COST ESTIMATES

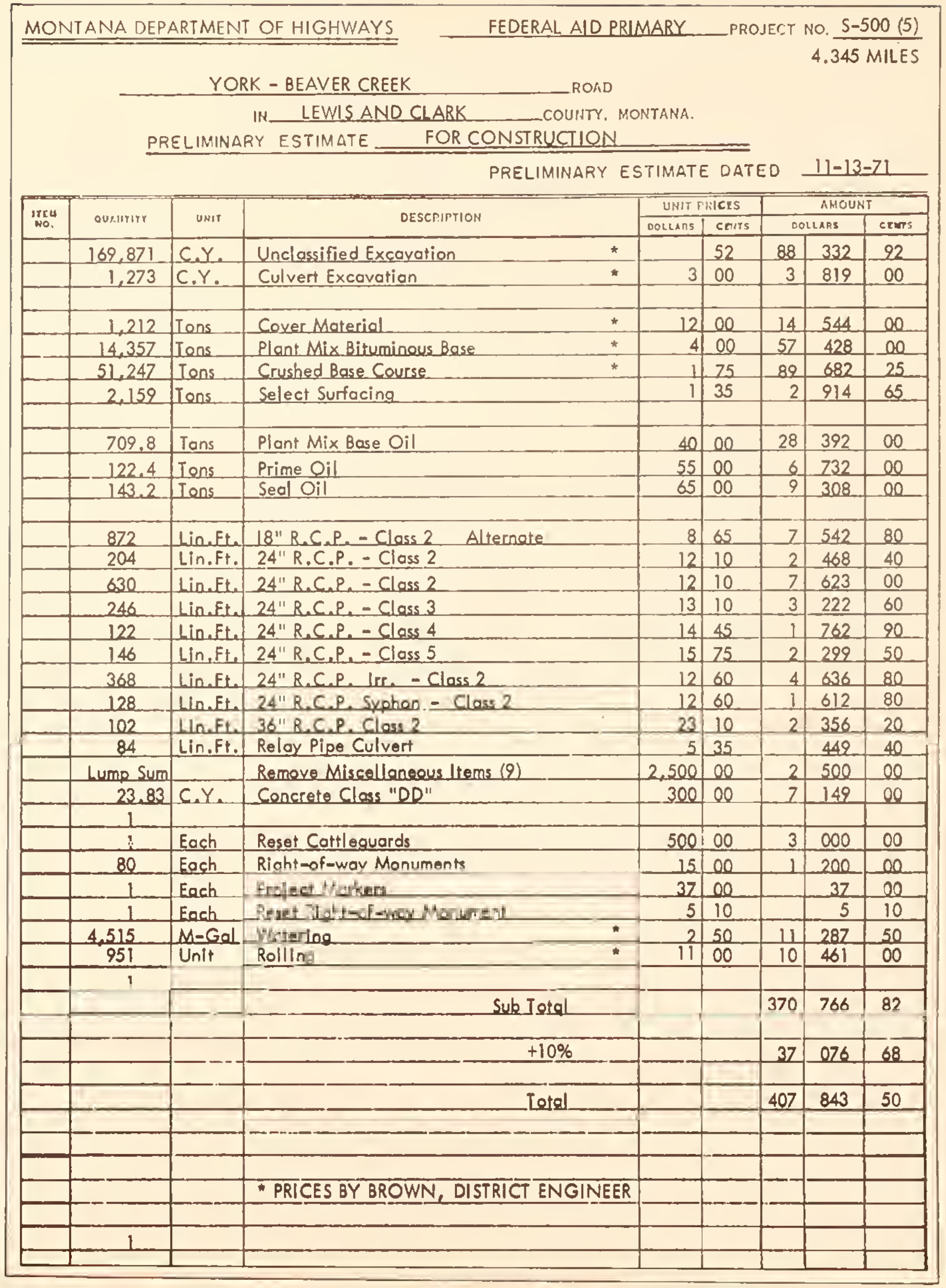
For each project, the designer usually will prepare two cost estimates. These are discussed below.

A cost estimate of grading, surfacing, and guardrail quantities will be made following the preliminary P.I.H. inspection. This cost estimate will be based on unit cost figures furnished by the District Engineer. This estimate will be used to update program amounts.

A detailed cost estimate showing all quantities will be prepared prior to the final P.I.H. inspection. For this cost estimate, the District Engineer will furnish updated unit costs for the major items. Average unit prices will be used for miscellaneous items such as pipe culverts and cattle guards.

Immediately prior to submitting the completed plans to the checker, the designer must update the quantities shown on the detailed cost estimate and revise the total cost of each item accordingly.

A properly completed cost estimate is shown at the right.



MONTANA DEPARTMENT OF HIGHWAYS FEDERAL AID PRIMARY PROJECT NO. S-500 (5)
4.345 MILES

YORK - BEAVER CREEK ROAD
IN LEWIS AND CLARK COUNTY, MONTANA.
PRELIMINARY ESTIMATE FOR CONSTRUCTION
PRELIMINARY ESTIMATE DATED 11-13-71

ITEM NO.	QUANTITY	UNIT	DESCRIPTION	UNIT PRICES		AMOUNT		
				DOLLARS	CENTS	DOLLARS		CENTS
	169,871	C.Y.	Unclassified Excavation *		52	88	332	92
	1,273	C.Y.	Culvert Excavation *	3	00	3	819	00
	1,212	Tons	Cover Material *	12	00	14	544	00
	14,357	Tons	Plant Mix Bituminous Base *	4	00	57	428	00
	51,247	Tons	Crushed Base Course *	1	75	89	682	25
	2,159	Tons	Select Surfacing	1	35	2	914	65
	709.8	Tons	Plant Mix Base Oil	40	00	28	392	00
	122.4	Tons	Prime Oil	55	00	6	732	00
	143.2	Tons	Seal Oil	65	00	9	308	00
	872	Lin.Ft.	18" R.C.P. - Class 2 Alternate	8	65	7	542	80
	204	Lin.Ft.	24" R.C.P. - Class 2	12	10	2	468	40
	630	Lin.Ft.	24" R.C.P. - Class 2	12	10	7	623	00
	246	Lin.Ft.	24" R.C.P. - Class 3	13	10	3	222	60
	122	Lin.Ft.	24" R.C.P. - Class 4	14	45	1	762	90
	146	Lin.Ft.	24" R.C.P. - Class 5	15	75	2	299	50
	368	Lin.Ft.	24" R.C.P. Irr. - Class 2	12	60	4	636	80
	128	Lin.Ft.	24" R.C.P. Syphon - Class 2	12	60	1	612	80
	102	Lin.Ft.	36" R.C.P. Class 2	23	10	2	356	20
	84	Lin.Ft.	Relay Pipe Culvert	5	35		449	40
	Lump Sum		Remove Miscellaneous Items (9)	2,500	00	2	500	00
	23.83	C.Y.	Concrete Class "DD"	300	00	7	149	00
	1							
	1	Each	Reset Cattleguards	500	00	3	000	00
	80	Each	Right-of-way Monuments	15	00	1	200	00
	1	Each	Project Markers	37	00		37	00
	1	Each	Reset Right-of-way Monument	5	10		5	10
	4,515	M-Gal	Watering *	2	50	11	287	50
	951	Unit	Rolling *	11	00	10	461	00
	1							
			Sub Total			370	766	82
			+10%			37	076	68
			Total			407	843	50
			* PRICES BY BROWN, DISTRICT ENGINEER					
	1							

FIELD INSPECTIONS

Chapter Fourteen

FIELD INSPECTIONS

GENERAL CONSIDERATIONS

During the design phase of each project, one or two plan-in-hand field inspections will be made to resolve design problems.

Designers will participate in plan-in-hand (P.I.H.) inspections only when specifically requested by the Senior Supervisor (Area Engineer). Other participants include:

- Senior Supervisor
- District Engineer
- Division Engineer
- District Right-of-Way Supervisor
- FHWA Area Engineers and Right-of-Way Engineers
- Specialists in hydraulics, traffic, bridges, etc. as requested
- Persons representing private and governmental interests that will be significantly affected.

One P.I.H. inspection should be adequate for projects when the major alignment, grade, drainage and access features appear to be rather simple. On more complex projects, two P.I.H. inspections will be expected: a preliminary P.I.H. inspection and a final P.I.H. inspection.

PRELIMINARY P.I.H. INSPECTIONS

Objectives

Preliminary P.I.H. inspections will be made to establish the alignments and the grades of projects. All problems relating to alignments and grades should be resolved at this time.

Preparations

To prepare for the preliminary P.I.H., the designer should review the proposed alignment and make a list of the problems to be resolved.

The plans to be taken on the preliminary P.I.H. are as follows:

- Title sheet
- Typical sections
- Plan and profile sheets showing proposed alignment, grade and drainage. The grade line and the drainage items will be drawn in pencil.
- One-page mass diagram with a grading summary attached
- Preliminary layouts of interchanges, rest areas and other facilities.

Preliminary P.I.H. Report

Following the preliminary P.I.H. inspection, a preliminary P.I.H. report will be prepared setting forth the revisions agreed to during the inspection. The report will be prepared by the designer if he participates in the inspection, or by the Senior Supervisor if the designer does not participate in the inspection. The report, when concurred in by the participants of the preliminary P.I.H. inspection, will be used as the basis for further development of the plans.

Revising the Plans

Revisions to the plans, as specified in the approved preliminary P.I.H. report, will be made by the designer before continuing with the detailed design. Upon completion of the revisions, any grade changes which affect structures must be sent to the Bureau of Bridge Design.

FINAL P.I.H. INSPECTIONS

Objectives

Final P.I.H. inspections will be made to establish all details needed to complete the design of the project. Decisions made during preliminary P.I.H. inspections relative to alignments, grades, and other items will not be reviewed unless major problems arise.

Preparations

To prepare for the final P.I.H. inspection, the designer should again review the project and make a list of the problems to be resolved.

The plans should be prepared in detail, with the details ready to trace. Right-of-way lines and grade lines will be drawn in pencil, and all paper summaries must be complete.

All special provisions should be written in draft form. When writing special provisions, designers will adhere to the requirements of PPM 40-3.1 and use the Department's Guidelines for Writing Specifications and Special Provisions.

A copy of the detailed cost estimate should be available during the final P.I.H. inspection.

Final P.I.H. Report

Following the final P.I.H. inspection, a final P.I.H. report will be prepared setting forth the revisions agreed to during the inspection. The report will be prepared by the designer if he participates in the inspection, or by the Senior Supervisor if the designer does not participate in the inspection. The report, when concurred in by the participants of the final P.I.H. inspection, will be used as the basis for revising the plans.

Revising the Plans

The designer will revise the plans, based on the approved final P.I.H. report, before tracing the final details.

PLANS ASSEMBLY

Chapter Fifteen

CONTRACT PLANS ASSEMBLY

GENERAL CONSIDERATIONS

Necessary Information

Guidelines for preparing road plans, utility plans and cross sections are presented in this chapter. The types of sheets to be included in contract plans are noted on the model Table of Contents in this chapter.

To ensure that the plans are clear and complete, they should contain neither more nor less information than required by the guidelines.

Simplicity

The contract plans should be prepared as simply as possible. Try to avoid the use of duplicate data and unnecessary cross references, as they merely complicate the tasks of revising and checking the plans.

Where possible, there should be no cross references to Standard Drawings.

Uniformity and Consistency

The contract plans will be prepared in a uniform and consistent manner, according to the guidelines presented in this chapter. In unusual circumstances not covered by the guidelines, designers should establish suitable guidelines to be used with consistency throughout the plans.

Size and Layout of Original Sheets

Original drawings will be on 22" x 36" sheets. Border lines on all sheets will provide 2 - inch binding margins and ½ - inch margins elsewhere, except that on cross-section sheets the border lines may be omitted if sufficient space is allowed for 2 - inch binding margins.

Pencil Drawings

Pencil drawings will be accomplished using an HB lead. Line widths should be the same as the widths of corresponding inked lines.

Sheet Identification

All sheets except title sheets will have a standard block in their upper right corners indicating the State, project number and sheet number.

Abbreviated Plans

Abbreviated plans consisting of title sheets, typical sections, summaries of quantities and general notes are acceptable for surfacing or surface widening projects on previously-constructed federal-aid projects. Plan and profile sheets will be included for any changes in alignment or grade.

Binding Original Plans

All original plans, including cross sections, should be bound on the left side with brass fasteners through holes that are punched uniformly on all types of plans.

TITLE SHEET

General Requirements

Title sheets will be the front covers of sets of plans. Title sheets will identify projects and project locations as described below and illustrated on the two model sheets.

State Map

A state map in the upper left corner of the sheet will show the general location of the project in relation to other roads within the State. An arrow labeled "This Project" will indicate the project location.

Title Information

Title information will be shown in the top center of the sheet in the following order:

- Montana Department of Highways
- Project construction number as shown on the program document
- Unit numbers and types of work covered by the set of plans
- Project name
- County name

Project Length

The project length will be shown to the nearest tenth of a mile immediately below the title information.

Scales

Scales of plan and profile sheets, cross sections and reduced sheets will be shown immediately below the project length.

The standard scale of layout maps is one inch per mile and should be used wherever practicable. Layout maps for urban-area work will show enlarged views of the urban areas affected.

Design Data

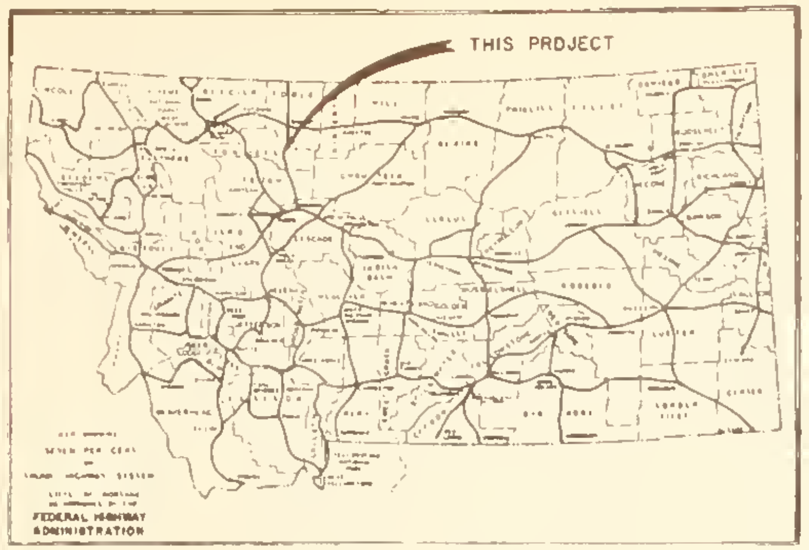
Project design data will be included in a block in the upper right corner. For those projects having two or more road segments with different design data, separate design data blocks will be prepared for each segment.

Letting Date

The letting date recorded in the upper right corner will represent the actual letting date, not the proposed letting date.

Project Approval Block

A project approval block will be shown in the lower right corner of the sheet.



MONTANA DEPARTMENT OF HIGHWAYS

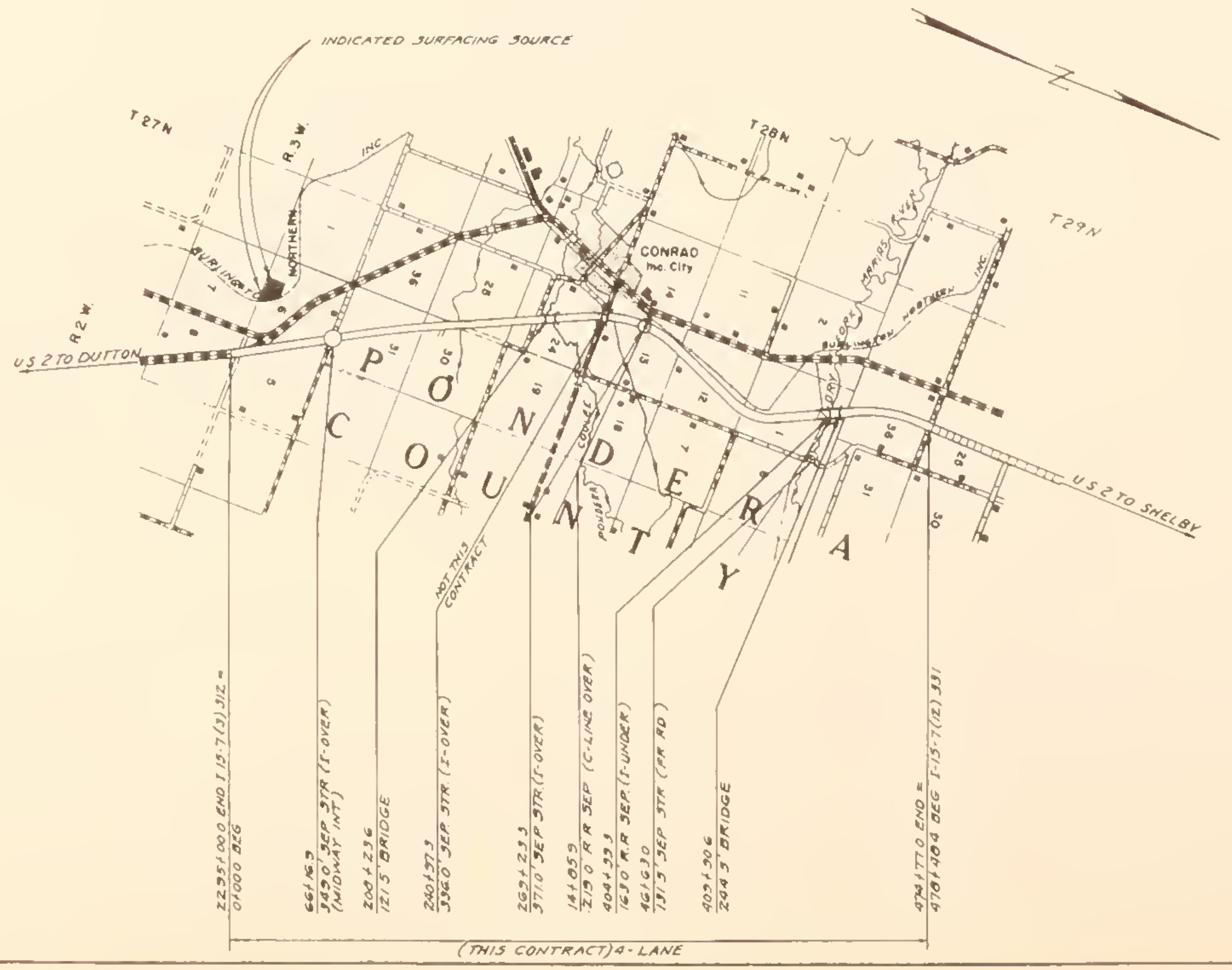
FEDERAL AID PROJECT I-IG 15-7 (13)323
U-1 GRADING & STRUCTURES
CONRAD NORTH & SOUTH
PONDERA COUNTY

LENGTH 9.0 **MILES**

SCALES
HORIZONTAL: 1 Inch= 100 Feet
VERTICAL: 1 Inch= 10 Feet
CROSS SECTIONS--HOR. & VERT.: 1 Inch= $\frac{10}{20}$ Feet
REDUCED PRINTS APPROX 1/2 ORIGINAL SCALE

DESIGN DATA		
A.D.T.	1962 =	1269
A.D.T.	1990 =	4550
D.H.V	=	640
D	=	55 - 45 %
T	=	15 %
V	=	70 M.P.H.

LETTING DATE ____________


INDICATED SURFACING SOURCE
N
T 27 N
T 28 N
T 29 N
R 3 W
R 2 W
CONRAD
Inc. City
P O N D E R A
C O U N T Y
US 2 TO DUTTON
US 2 TO SHELBY
BURLINGTON NORTHERN INC.
PONDERA COULEE
DRY FORK MARIAS RIVER
NOT THIS CONTRACT
2235+00.0 END I 15-7(3)312 = 0+00.0 BEG
66+16.9 349.0' SEP STR (I-OVER) (MIDWAY INT.)
200+23.6 121.5' BRIDGE
240+57.3 336.0' SEP STR (I-OVER)
269+23.3 371.0' SEP STR (I-OVER)
14+05.9 219.0' R.R. SEP (C-LINE OVER)
404+33.3 163.0' R.R. SEP (I-UNDER)
461+63.0 131.5' SEP STR (FR RD)
409+30.6 204.5' BRIDGE
474+77.0 END = 4781+40.4 BEG I-15-7(12) 331
(THIS CONTRACT) 4-LANE

RELATED PROJECTS
U-2 FENCING U-3 STRUCTURE F-149 (7)

ASSOCIATED PROJECT AGREEMENT NUMBERS	
R/W B I C.	(6) 323
P E	(1) 328 (8) 323

MONTANA DEPARTMENT OF HIGHWAYS

APPROVED

____________ 19 ____

STATE HIGHWAY ENGINEER

No 174ES
LEWIS M. CHITTIM

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED

DIVISION ENGINEER

DATE

Layout Map

A layout map in the bottom center of the sheet will clearly show the following:

- The location of the project roadway in relation to true north, nearby townships, ranges, sections, existing roads, towns, major drainage, state-optioned borrow and surfacing sources, railroads and buildings
- The beginning and ending stations of the project
- The numbers and stations of other projects onto which the project is tied
- Names of interchanges
- Separation structures and bridges on the project. A single station number, based on mainline stationing, will represent the approximate center of each structure. Data will indicate the length of each structure, whether it is an overpass or underpass in relation to the main line and whether it is to be constructed in the contract.
- Signed route numbers for U.S., State and Secondary Highways
- Enlarged maps of cities and towns where construction is contemplated through those areas. An example is shown on the next page.

Care should be taken to see that nonoptioned surfacing or borrow pits are not shown on the layout map or elsewhere on the title sheet.

Associated Project Agreement Numbers

Associated project agreement numbers for right-of-way, incidental construction and preliminary engineering will be shown in the lower left corner of the sheet.

Related Projects

A block for Related Projects will be shown above the associated project agreement numbers. Data to be included under "Related Projects" are contract units not covered by the contract plans and numbers of projects financially related to the main project.

Preprinted Title Sheets

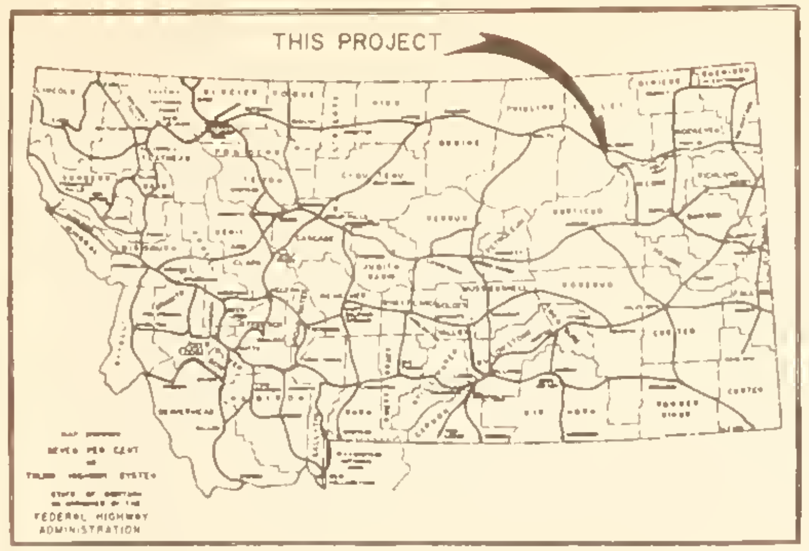
Preprinted title sheets are available and should be used wherever practicable. Preprinted sheets show the state map and blocks for design data, project approvals, related projects and associated project agreement numbers. Also shown are the Department name and standard data for scales and project length.

Drafting

Title sheets should be drafted as follows:

Leroy:	Title information	425 template
	Mileage	290 template
	Boxed information	140 template
Handletter:	Layout map information	No. 1 pen

The north arrow on finished plans will be uniform within each set of plans.



MONTANA DEPARTMENT OF HIGHWAYS

FEDERAL AID PROJECT F-155 (9)

GRADE, GRAVEL, PLANT MIX SURF. & STRUCTURES

GLASGOW - WEST

VALLEY COUNTY

LENGTH 4.1 MILES

SCALES

HORIZONTAL: 1 Inch= 100 Feet
VERTICAL: 1 Inch= 10 Feet
CROSS SECTIONS--HOR. & VERT.: 1 Inch= 10 Feet
REDUCED PRINTS APPROX 1/2 ORIGINAL SCALE

DESIGN DATA

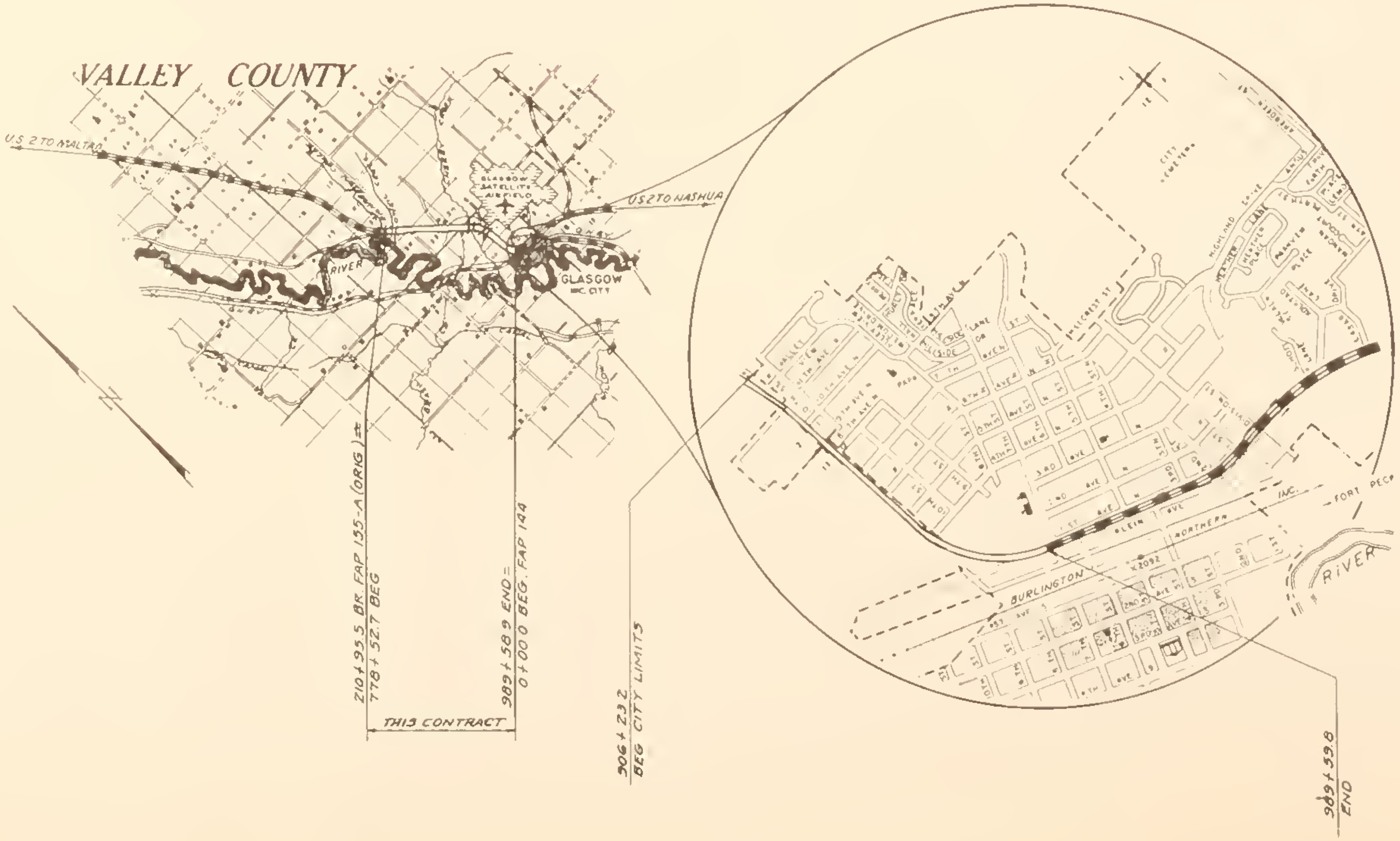
AOT 1970 - 1895
AOT 1990 - 3800
OHV 360
O 55% - 45%
T 35%
V 70 M.P.H.

RURAL

ADT 1970 - 8920
AOT 1990 - 15.100
OHV 980
O 55% - 45%
T 19%
V 50 M.P.H.

URBAN

LETTING DATE ______



RELATED PROJECTS
NONE

ASSOCIATED PROJECT AGREEMENT NUMBERS	
P.E.	(7)
R/W & I C	(8)

MONTANA DEPARTMENT OF HIGHWAYS

APPROVED

______ 19 ____

STATE HIGHWAY ENGINEER

No 174ES
LEWIS M. CHITTIM

U S DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED

DIVISION ENGINEER DATE

SYMBOLS AND ABBREVIATIONS SHEET

The model symbols and abbreviations sheet on the next page will be printed on the back of every title sheet. The model sheet shows all the standard symbols and abbreviations adopted by the Department.

The standard symbols and abbreviations will be used with consistency in all sets of contract plans. It should be observed that certain items are represented by different symbols, depending on the sheet or view where they are depicted.

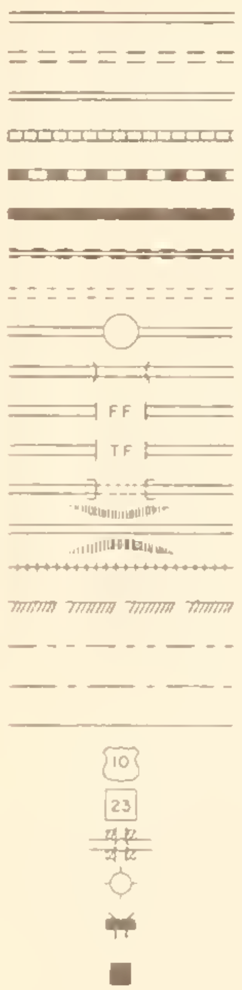
Abbreviations should be used only where restricted room prevents the writing of complete words.

Preprinted symbols and abbreviations sheets are available for use in preparing contract plans.

SYMBOLS & ABBREVIATIONS

STATE	PROJECT NO	SHEET NO
MONTANA	I-IG-15-7(13)323	3

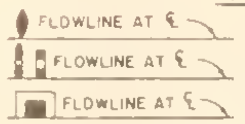
TITLE SHEET



PRIMARY ROAD*
PRIMITIVE ROAD
PROPOSED ROAD
GRADED ROAD
GRAVELED ROAD
PAVED ROAD
FEDERAL AID ROUTING (On Existing Road)
FEDERAL AID ROUTING (Non-existent Road)
INTERCHANGE
STRUCTURE
FREE FERRY
TOLL FERRY
HIGHWAY TUNNEL
PASS
RAILROAD
RESERVATION LINE
STATE & NATIONAL LINE
COUNTY LINE
TOWNSHIP & SECTION LINE
U S HIGHWAY
STATE HIGHWAY
CITY OR TOWN
AIR FIELD
DAM
BUILDING

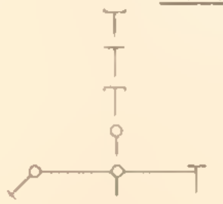
Primary roads are 08 inch wide All others are 05 inch wide

PROFILE



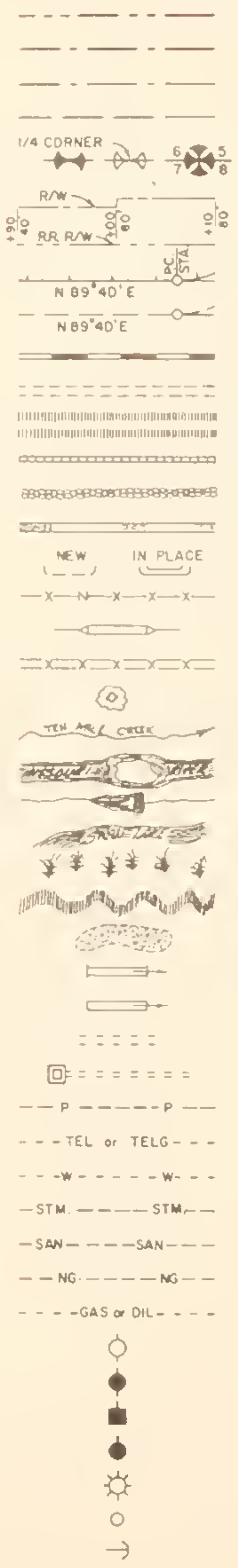
CULVERT
IRRIGATION SYPHON
CONCRETE BOX CULVERT

CROSS SECTIONS



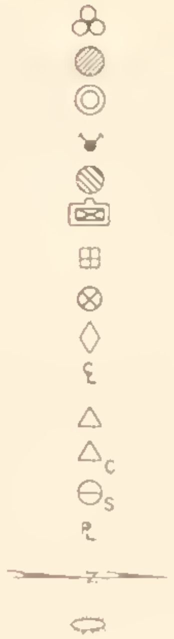
POWER POLE (No of Wires & Voltage)
TELEPHONE POLE (No of Wires)
TELEGRAPH POLE (No. of Wires)
GUY POLE
GUY AND ANCHOR

PLAN



STATE & NATIONAL LINE
COUNTY LINE
CITY OR TOWN BOUNDARIES
TOWNSHIP LINE
SECTION LINE (Showing corner solid if found-open if not found)
HIGHWAY RIGHT-OF-WAY
RAILROAD RIGHT-OF-WAY
BASE OR SURVEY LINE
℄ OF STAKED LINE WHEN A PROJECTION IS MADE
RAILROAD
TRAVELED WAY
LEVEE OR DYKE
RETAINING WALL
RIPRAP
CONCRETE SIDEWALK
CONCRETE CURB
FENCE LINE
CATTLE GUARD
SNOW FENCE
TREE OR BUSH
SMALL DRAINAGE
LARGE DRAINAGE
RESERVOIR WITH DAM
LAKE
MARSH, SWAMP
BLUFFS OR CLIFFS
GRAVEL PIT
CULVERT WITH HEADWALL (In Place)
CULVERT WITHOUT HEADWALL (In Place)
NEW CULVERT OR EMBANKMENT PROTECTOR
DROP INLET, MEDIAN INLET OR CATCH BASIN
POWER CABLE
TELEPHONE OR TELEGRAPH CABLE
WATER LINE
STORM SEWER
SANITARY SEWER
NATURAL GAS LINE
GASOLINE OR OIL LINE
TELEGRAPH POLE
TELEPHONE POLE
POWER POLE
TROLLEY POLE
LIGHT POLE
GUY POLE
GUY WIRE & ANCHOR

PLAN



OIL OR GAS WELL
TANKS
MANHOLE (Label as to type or service)
HYDRANT
WATER WELL
SCALES
PROJECT MARKER
STATION MARKER
R/W MONUMENT
CENTERLINE
DEFLECTION ANGLE
DEFLECTION ANGLE (Circular Curve)
DEFLECTION ANGLE OF ONE SPIRAL
PROPERTY LINE
NORTH ARROW
DITCH BLOCK

ABBREVIATIONS

ADD EXC	ADDITIONAL EXCAVATION
A D T	AVERAGE DAILY TRAFFIC
AGG	AGGREGATE
AH	AHEAD
APP	APPROACH
APPL	APPLICATION
APPROX	APPROXIMATE
ASPH	ASPHALT
AV	AVERAGE
BBLS	BARRELS
BEG	BEGIN
B E	BRIDGE END
BIT	BITUMINOUS or BITUMEN
BK	BACK or BANK
BLDG	BUILDING
BLK	BLOCK
B M	BENCH MARK
BOT	BOTTOM
BR	BRIDGE
B R	BASE of RAIL
B S T	BITUMINOUS SURFACE TREATMENT
C	CUT
C & G	CURB & GUTTER
C/A	CONTROL of ACCESS
C A P	CORRUGATED ALUMINUM PIPE
CEM	CEMENT
CH	CHANNEL
CH CH	CHANNEL CHANGE
CL	CLASS or CLEARANCE
CO	COUNTY or COMPANY
COMP	COMPACTION
CONC	CONCRETE
CONN	CONNECTION
CONST	CONSTRUCTION
COR	CORNER
COV	COVER
CR	CRUSHED or CREEK
CRS	COURSE
C S	CURVE to SPIRAL
C S P	CORRUGATED STEEL PIPE
C S P A	CORRUGATED STEEL PIPE ARCH
CTR	CENTER
CULV	CULVERT
C Y	CUBIC YARD
D	DEGREE of CURVATURE or DISTRIBUTION of TRAFFIC
D_c	DEGREE of CURVATURE (with spirals)
DET	DETOUR
DHV	DESIGN HOURLY VOLUME
D I	DROP INLET
DR	DRAIN
DT	DITCH
DWG	DRAWING
E	EAST
E B	EASTBOUND
ELEV	ELEVATION
ELONG	ELONGATED
EMB	EMANKMENT
EMUL	EMULSIFIED
E O	EDGE of OIL
EQ	EQUATION
ESMT	EASEMENT
EX.	EXISTING
EXC	EXCAVATION
EXT	EXTENSION or EXTERNAL
F	FILL
F A	FEDERAL AID
FE	FENCE
FERT	FERTILIZER
F E T S	FLARED END TERMINAL SECTION
FIN	FINISH
F L	FLOW LINE
FR	FRONTAGE
FT	FOOT
FUT	FUTURE
G	GRADING
GA	GAGE
GAL	GALLON
GALV	GALVANIZED
GAR	GARAGE
G R	GUARD RAIL
GR	GRADE
G S	GRAVEL SURFACING
GTR	GUTTER
H & T	HUB & TACK
HDWL	HEADWALL
HG.	HEADGATE
HO	HOUSE
HOR	HORIZONTAL
HT	HEIGHT
HWY	HIGHWAY
H W	HIGH WATER
I	INTERSTATE
I C	INCIDENTAL CONSTRUCTION
INC	INCORPORATED
INCL	INCLUDED
INT	INTERCHANGE
I. P	IRON PIN
IRR	IRRIGATION
L	LENGTH of CURVE
LBS	POUNDS
L_c	LENGTH of CIRCULAR CURVE
LENG	LENGTH-LENGTHEN
L.F	LINEAR FEET
L_s	LENGTH of SPIRAL
LT	LEFT
MATL	MATERIAL
MAX	MAXIMUM
M C	MEDIUM CURING
MED	MEDIAN
MH.	MANHOLE
MIN	MINIMUM, MINERAL or MINUTE
MISC	MISCELLANEOUS
M L	MAINLINE
MNCPL	MUNICIPAL
MON	MONUMENT
M Y	MILE YARD
N	NORTH
N B	NORTHBOUND
N.C	NORMAL CROWN
N E	NORTHEAST
N G	NATURAL GAS
N.W	NORTHWEST
O'PASS	OVERPASS
P	POWER CABLE
P C	POINT of CURVE (Beginning)
P C C	POINT of COMPOUND CURVE or PORTLAND CEMENT CONCRETE
P E	PRELIMINARY ENGINEERING
PAVT	PAVEMENT
PEN	PENETRATION
PERF	PERFORATED
P.I	POINT of INTERSECTION
PL	PLACE
P M B	PLANT MIX BASE
P.M S	PLANT MIX SURFACING
P O C.	POINT on CURVE
P O. S	POINT on SPIRAL
P O S T	POINT on SEMI-TANGENT
P O T	POINT on TANGENT
P P	POWER POLE
PREST	PRESTRESSED
PROC	PROCESSING
PROJ	PROJECT or PROJECTED
PROT	PROTECT, PROTECTOR or PROTECTION
PT.	POINT
P. T	POINT of TANGENT (End of Curve)
P T W	PRESENT TRAVELED WAY
PWR	POWER (Lines)
Q	PEAK DISCHARGE (Water)
R	RANGE, CURVE RADIUS, RISE
R C	RAPID CURING
R.C P.	REINFORCED CONCRETE PIPE
R C. P A	REINFORCED CONCRETE PIPE ARCH
RD	ROAD
RDWY	ROADWAY
REINF	REINFORCEMENT
R R	RAILROAD
RT	RIGHT
R/W	RIGHT of WAY
RTE	ROUTE
RY	RAILWAY
S	RATE of FULL SUPERELEVATION, SLOPE in FT per FT, SPAN or SOUTH
S B	SOUTHBOUND
S C	SLOW CURING
S C	SPIRAL to CURVE
SDWK	SIDEWALK
S E	SOUTHEAST
SEC	SECTION or SECOND
SH	SHOULDER
SHT	SHEET
SPEC. PROV	SPECIAL PROVISION
SAN SEW	SANITARY SEWER
S S P P A C	STRUCTURAL STEEL PLATE PIPE ARCH CULVERT
S S	EMULSIFIED ASPHALT
S T	SPIRAL to TANGENT
ST.	STREET
STA	STATION
STL	STEEL
STD	STANDARD
STD SPEC	STANDARD SPECIFICATIONS
STK	STAKED or STAKE
STM SEW	STORM SEWER
STR.	STRUCTURE
SUBGR	SUBGRADE
SURF	SURFACE
S. W	SOUTHWEST
SYP	SYPHON
S Y	SQUARE YARD
T	TOWNSHIP, TANGENT LENGTH or PERCENT TRUCKS
TBR	TIMBER
TEL	TELEPHONE
TELG	TELEGRAPH
TRANS	TRANSMISSION LINE or TRANSITION
T_s	LENGTH of TANGENT (Curve with Spirals)
T S	TANGENT to SPIRAL
TYP	TYPICAL
U	UNIT
UNC	UNCLASSIFIED
U'PASS	UNDERPASS
V	DESIGN SPEED or VELOCITY
V C	VERTICAL CURVE
VEH	VEHICULAR
VERT.	VERTICAL
VIT.	VITRIFIED
W	WEST
W B.	WESTBOUND
W T.	WATER TABLE
WT	WEIGHT
X-ING	CROSSING
X-SECT	CROSS SECTION

TABLE OF CONTENTS SHEET

General Requirements

A table of contents will be included in each set of contract plans, consistent with the model on the next page. One sheet will be used solely for the table of contents, except in plans so brief that the notes or notes and linear and level data may be readily placed on the same sheet.

Where the table of contents is combined with notes or notes and linear and level data, each group of information will be clearly labeled "TABLE OF CONTENTS," "NOTES" and "LINEAR AND LEVEL DATA" with the letter size used for sheet headings.

Sheet Sequence

Tables of contents will indicate the major groups of sheets and those subgroups necessary to facilitate locating each item in the plans. The major groups of sheets are listed below in the proper order. Colors of the printed sheets are indicated in parentheses.

1. Road plans (white)
2. Signing plans (yellow)
   Signing plans include plans for both permanent and construction signing.
3. Electrical plans (blue)
   Electrical plans include plans for both lights and signals.
4. Bridge plans (green)
5. Utility plans (white)
6. Cross Sections (white)
7. Addenda (buff)

Sheets within the various groups will be sequenced as shown on the model sheet.

Sheet Numbers

The title sheet will be considered as page one, but it will not be numbered. All other sheets will have sheet numbers in their upper right corners. Sheets printed on both sides will be numbered separately on each side.

Road plans will be numbered with separate, sequential whole numbers. Signing, electrical, bridge and utility plans will be numbered separately within each group and will have those letter prefixes shown on the model sheet. Cross-section sheets will be numbered with separate, sequential whole numbers beginning with 1. Sheets added to a set of plans after final numbering (addenda) will be numbered sequentially within each major group as shown on the model.

Addenda

Tables of contents will indicate addenda -- sheet changes after final numbering-- as shown on the model. Each addendum and each attachment within the addendum will be numbered.

Attachments will be identified by sheet name, sheet number and whether they are revisions, additions or deletions. The first attachment to each addendum will be a revised table of contents showing the addendum and the revision date.

Drafting

Tables of contents should be Leroy lettered as follows:

Sheet heading	425 template
Sheet groups	200 template
Other information	175 template